SHORE EROSION STUDY

TECHNICAL REPORT

APPENDIX 5

SHORELINE EROSION AND BLUFF STABILITY ALONG LAKE MICHIGAN AND LAKE SUPERIOR SHORELINES OF WISCONSIN

SHEBOYGAN COUNTY

D. Hadley

C. Fricke

T. Edil

B. Haas

APRIL 1977

WISCONSIN
COASTAL MANAGEMENT

This report has been prepared through the cooperative efforts of the Wisconsin Geological and Natural History Survey, the University of Wisconsin (Madison, Milwaukee, Parkside and Extension), the Wisconsin Department of Natural Resources and the Office of State Planning and Energy. Assistance was further provided by Owen-Ayres and Associates.

This report is being reproduced quickly and in a limited quantity for dissemination to local governments and interested parties. The report will be broadly available when reproduced in the fall of 1977 as an information circular from the Wisconsin Geological and Natural History Survey.

Financial assistance for this study has been provided by the Coastal Zone Management Act of 1972 administered by the federal Office of Coastal Zone Management, National Oceanic and Atmospheric Administration.

SHORE EROSION STUDY

TECHNICAL REPORT

Appendix 5

Sheboygan County
Wisconsin

D. Hadley, C. Fricke
(Geology)

T. Edil, B. Haas
(Geotechnical Study)

INTRODUCTION

This Appendix provides detailed information on shoreline conditions within much of the county. The order of materials in the Appendix is from south to north. Parts of the shoreline are broken down by reach (see County Map) and geographic section within each reach. There is a text which describes the characteristics of shoreline conditions at the beginning of each reach section. This is accompanied by a map of the whole reach which shows the sections, public perception of erosion hazards, shore damage in 1952, short- and long-term recession rates, bluff height, shore protection structures, houses per mile, and boat ramps.

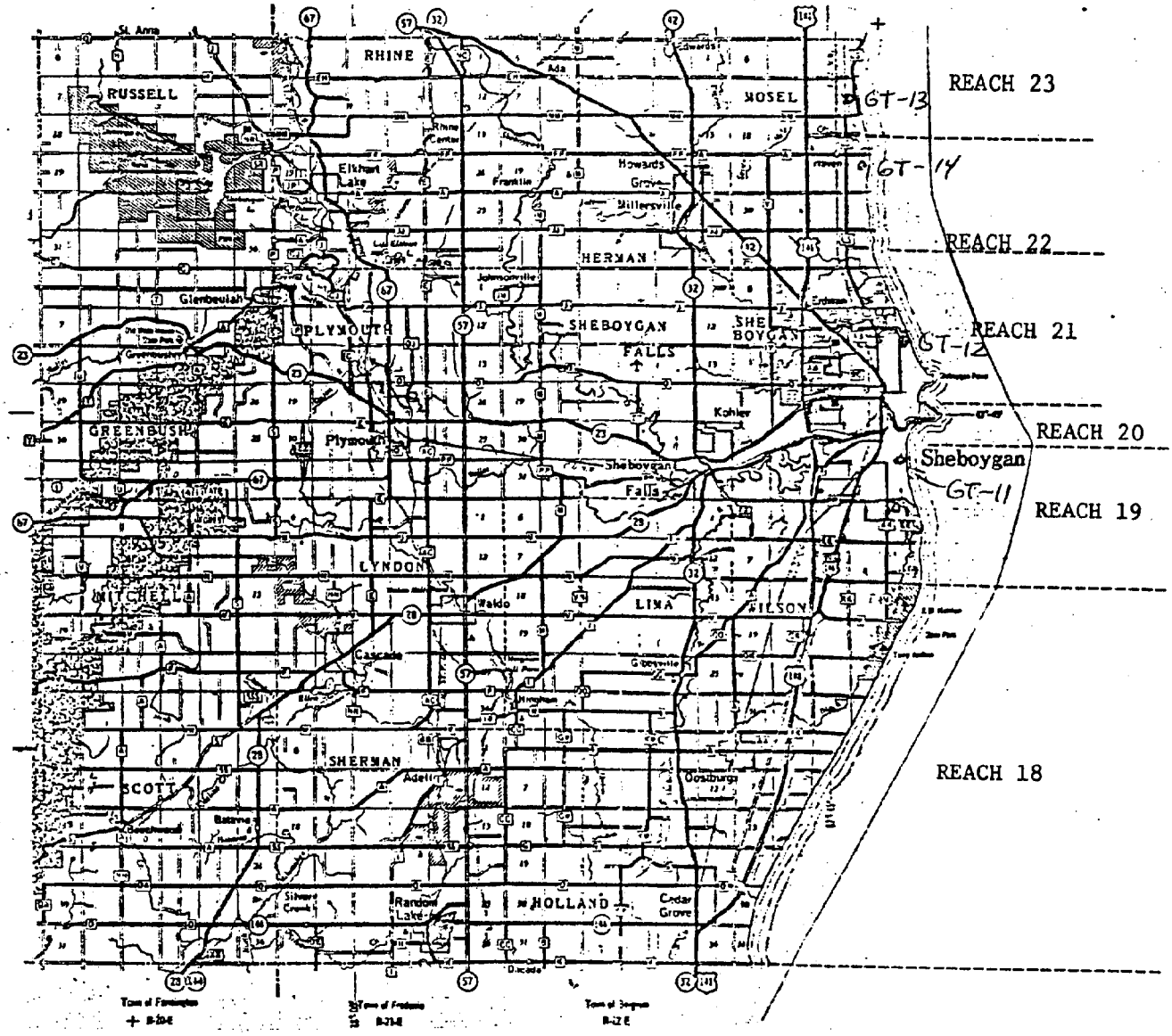
Location of geotechnical borings is indicated on the county map at the beginning of the Appendix. Logs for geotechnical holes and detailed location maps are given at the end of all of the maps in the reach containing that geotechnical site. For each geographic section (one mile long) a map showing the location of shore protection structures which are numbered and described in reports on file with the Department of Natural Resources. Also on the map, locations of measured profiles are shown along the shoreline. A running description of bluff characteristics, materials making up the toe of the slope, and beach characteristics is also given. Engineering data such as safety factor, the confidence level on this safety factor, and the distance the slope must retreat to attain a stable slope angle is also given. It should be noted that this distance assumes no wave cutting at the base of the bluff. This distance is referred to in the text as a stable slope distance. Also included with each section is a set of profiles from the water's edge to the bluff top. These profiles show stratigraphy, slope angles, circles of failure, and calculated safety factors along the shoreline. The dis-

tance to a 5 foot depth of water is also given. The date when the profile was measured is also given. Remember that the bluff profile could have changed since the profiles were measured.

The meaning of abbreviations used in the Appendix is given on this page. For more detailed description of the methods used in compiling the data, regional interpretations, and conclusions about the engineering characteristics and types of slope failure taking place refer to the main report (Shoreline Erosion and Bluff Stability Along Lake Michigan and Lake Superior Shorelines of Wisconsin) available from the State Planning Office and the Wisconsin Geological Natural History Survey.

Symbols Used
(used as nouns and adjectives)

b	boulders
c	clay or clayey
co	coarse
f	fine
g	gravel
m	medium
p	pebbles
s	sand
si	silt
t	till
y	cobbles
t(1A)	till name
SF	Factor of Safety A - unsatisfactory (1.00) B - questionable (1.00-1.25) C - satisfactory (1.25)
CL	Confidence Level A - high confidence - at borehole B - medium confidence - near borehole, stratigraphy visible C - low confidence - away from borehole, stratigraphy questionable
SL	Stability line - the distance slope must retreat to attain a stable slope angle. This assumes no erosion at toe and unchanged conditions of nature of material and water table.



SHEBOYGAN CO.
DEPARTMENT OF TRANSPORTATION

FIELD REPORT - REACH 18A

Location and General Description

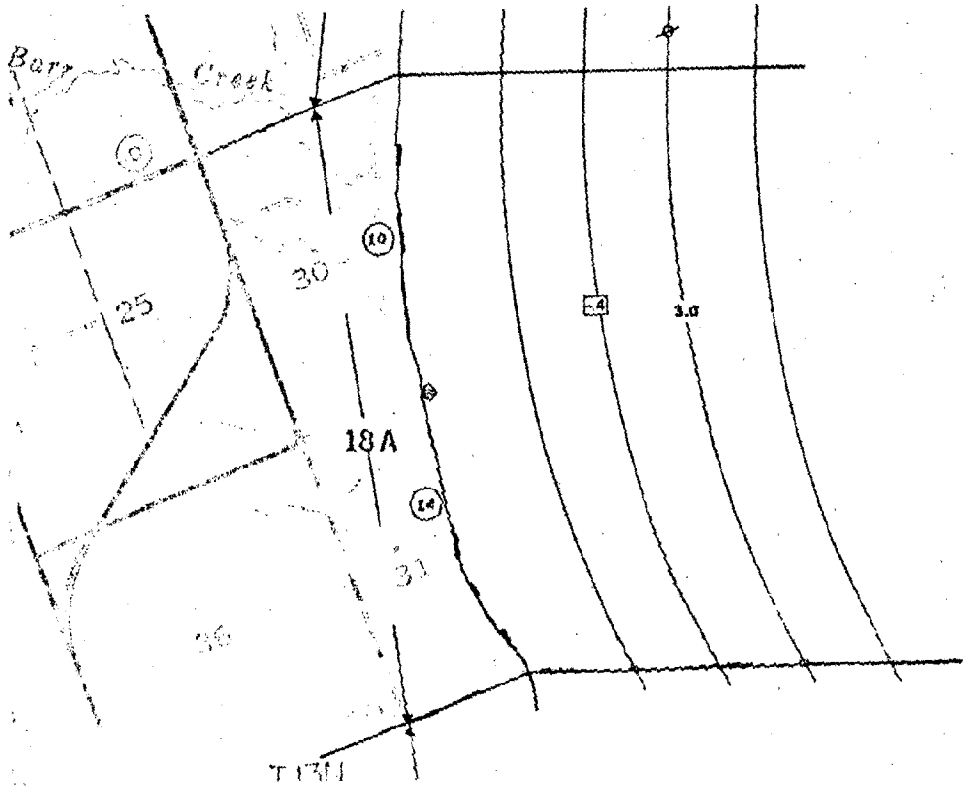
Reach 18A lies in Sections 30 and 31 of T.13N., R.23E. in extreme southern Sheboygan County. It is roughly two miles in length, extending from the county line on the south to a point directly east of the town of Cedar Grove. The reach has an overall priority of 18 which is the fourth highest priority of those reaches lying north of the Sheboygan County line.

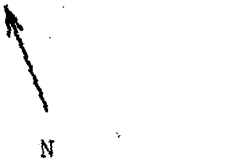
Reach 18A (along with Reaches 18B and 18C) lies on the prominent terrace that extends from just north of Port Washington to near the southern city limits of Sheboygan. This terrace was formed by shoreline erosion along the shores of an ancient glacial lake at a time when the lake level was about 605 feet above sea level. This is about 25 feet higher than modern Lake Michigan. The surface of the terrace is made up of a series of roughly parallel ancient beach ridges and is bordered on the west by an ancient wave cut bluff. This bluff is identical in origin to the steep bluffs that are found along many sections of the modern Lake Michigan shoreline in Sheboygan County and elsewhere. The terrace is believed to be of Nippissing Age.

Land use within Reach 18A is almost exclusively private residential, although a small township park is located on the extreme northern end of Sec. 31. Some summer cottages or second homes were observed, but most of the properties appear to be permanent residences.

Section 31

At the Sheboygan-Ozaukee County line, which is the southern border of this section, the terrace is roughly 1000 feet in width and terminates to the west at a relatively steep and well defined bluff which is between 30 and 40 feet high. Although the ancient bluffs were not studied in detail, the few exposures that were studied indicated 10 to 20 feet of red till over lacustrine sand and gravel.


Barr
Creek
9
10
30
25
3.0
18A
14
31
36
T13N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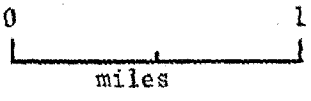
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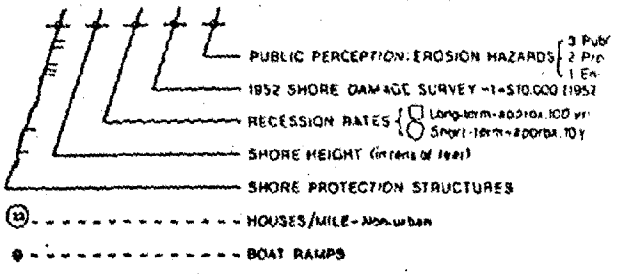
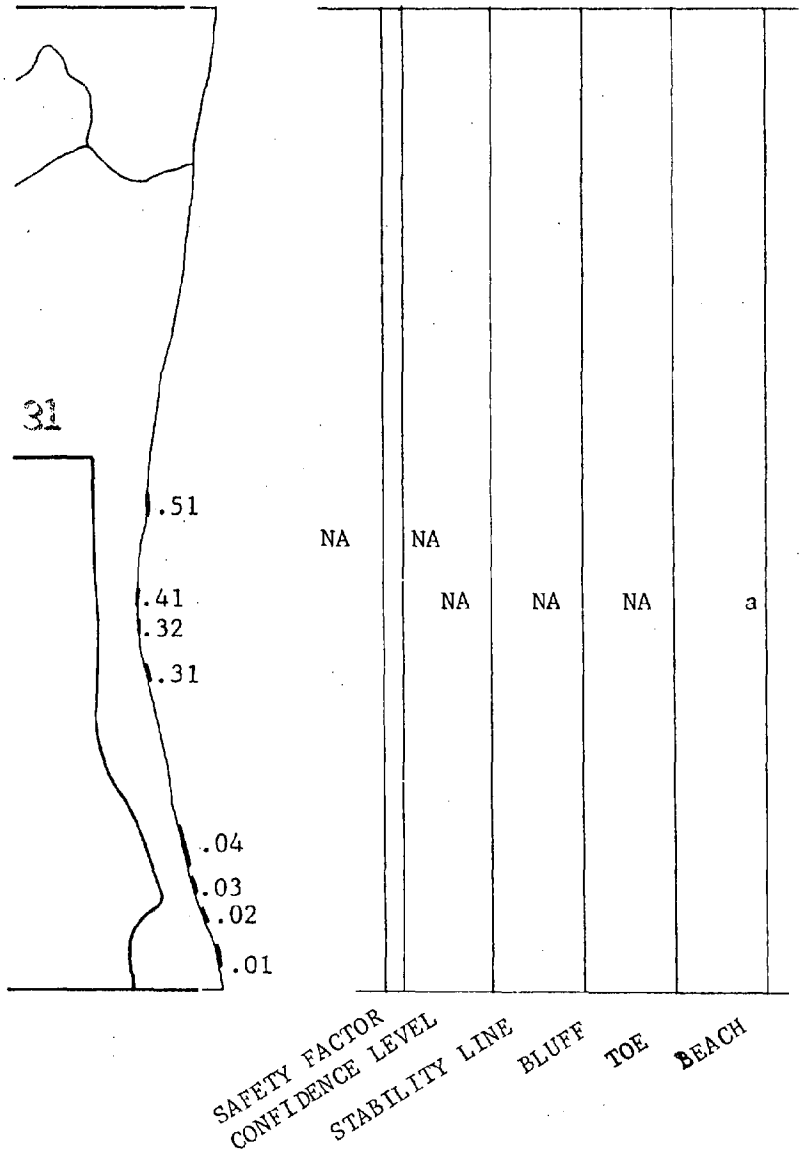
miles

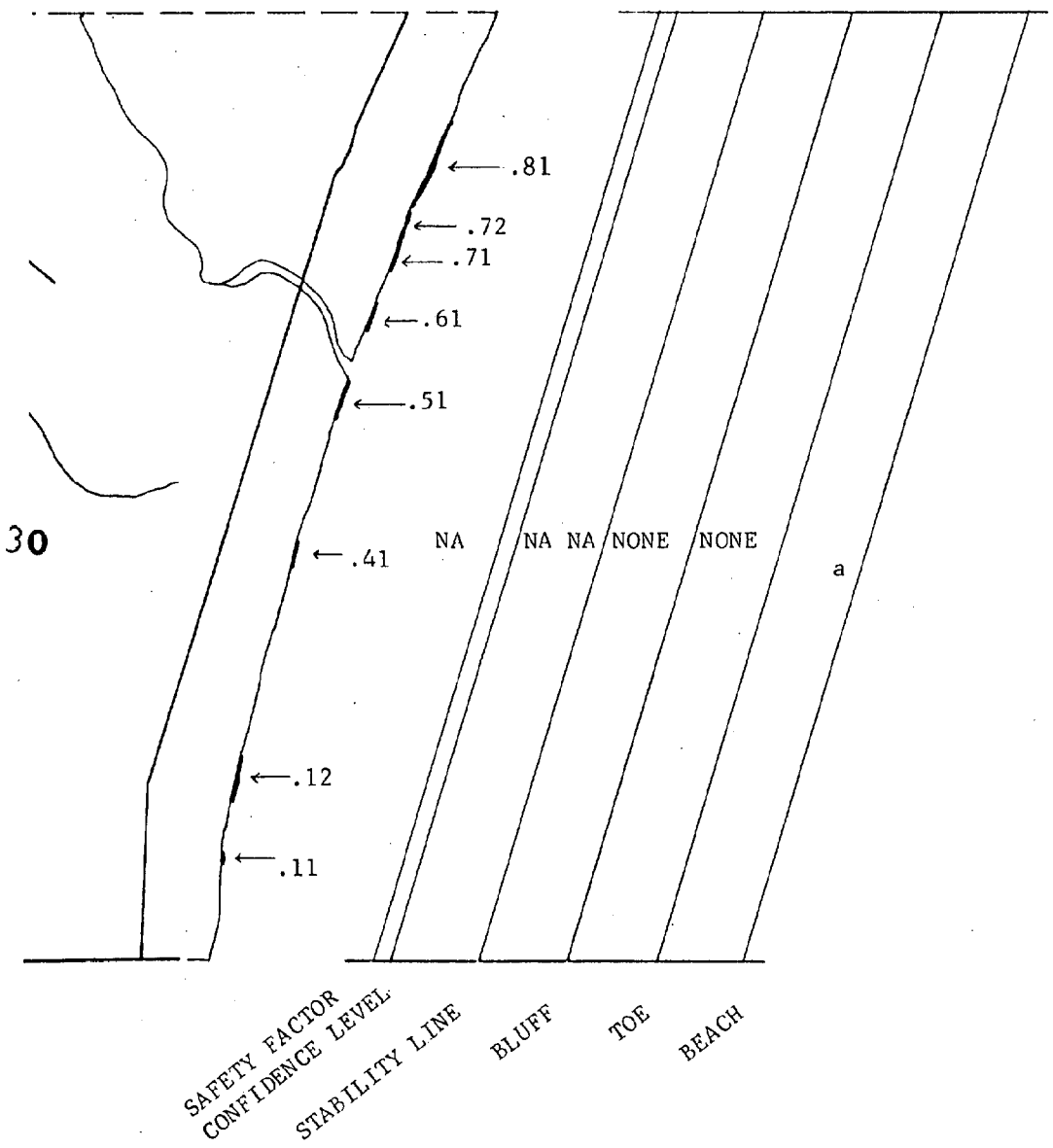
REACH 18A


PUBLIC PERCEPTION: EROSION HAZARDS
1952 SHORE DAMAGE SURVEY
RECESSION RATES
SHORE HEIGHT
SHORE PROTECTION STRUCTURES
HOUSES/MILE
BOAT RAMPS

T.13N.,R.23E.,Sec.31



1. BLUFF	none	
2. TOE	none	
3. BEACH	a-0-85 ft. sand	



SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	none	
2. TOE	none	
3. BEACH	a-40-100 ft. sand	

Housing density was given as 10 houses per mile. There were 8 structures described within the section. All of these structures were bulkheads, a number of which were of fairly heavy construction, with large glacial boulders serving as a fronting rip-rap. Available recession rate data were somewhat contradictory, with a short term average of 2.7 feet per year of erosion and a 100 year average showing an accretion of .4 feet per year. At the time of examination, erosion appeared to be the dominant process.

Barr Creek empties into the lake at about 31.7. At the time the area was investigated, the mouth of this stream was completely choked off by a beach bar. In periods of heavy precipitation, this bar normally would be breached, and a small delta would form at the outlet.

FIELD REPORT - REACH 18B

Location and General Description

Reach 18B encompasses all or part of Sections 19, 20, 17, 8, 9, and 4 of T.13N., and Sections 33 and 34 of T.14N., R.23E. The reach has an overall priority rating of 8 which is the highest of any reach north of the Sheboygan County line. Land use is almost exclusively private residential. Housing density varies from a low of 10 to a high of 45 residences per mile with an average density of about 27 residences per mile.

In the southern portions of the reach the beaches are well developed but as one progresses northward, the beaches narrow and many of the residences in the northern portion of the reach would suffer rapid and severe erosion losses if they were not heavily protected. The beaches are still predominantly sand when present with pebbles and cobbles significantly more abundant in the northern portion of Reach 18B than was true of the south.

As was the case in Reach 18A, the near back shore area is made up of sand dunes and beach ridges with cut faces ranging up to 18 feet in height.

Ancient bluffs lie approximately 1000 feet to the west of the present shore line in the southern portions of the reach. These bluffs are sharp and well defined in this area. As we move to the north the terrace broadens to about a quarter of a mile and the bluffs become obscure due to erosion by the streams tributary to the Black River. Annual erosion over about the last 10 years has been measured at between 2 and 3 feet per year while 100 year averages are significantly lower with values of about 0.5 feet per year.

Sections 19 and 20

These 2 sections are considered together since portions of each lie within a north-south mile along the Lake Michigan shoreline. Conditions along this segment of shoreline are similar to those described to the south in Reach 18A. An ancient bluff is separated from the modern shoreline by a lake terrace about 1000 feet in width. The face cut into this terrace by erosion along the modern lake exposes a combination of beach ridges and sand dunes.

Along undeveloped segments of the shoreline, beaches are about 65 feet wide. Evidence of rapid recent erosion is present in those areas where effective bulkheads have been constructed. Here, beach widths are often in the range of 0 to 10 feet.

Housing density was given as 22 houses per mile which is substantially greater than in Reach 18A to the south. No long term recession rate averages were available. A shore term average of 3.1 feet per mile had been obtained for a point near the junction of section 19 and 20. Ten structures were described in the section. All either bulkheads, revetments or a combination of the two structure types. Although these structures were of light construction, a number of them appeared to be effective in preventing erosion.

The distance off shore to a water depth of 5 feet ranged between 135 to 150 feet throughout the length of the section.

Section 17

This section is very similar to those described to the south, with the shore zone consisting of an ancient bluff separated from the modern shoreline by a sandy terrace. Housing density is given as 28 houses per mile. In the sections to the south almost all of the residential development was in the immediate shore zone. By contrast, in this section there has been a significantly greater development of the surface of the terrace.

The erosion rate data show a long term rate of 3 feet per year and a long term rate of 0.4 of a foot per year.

Fifteen structures were described along this section of the shoreline. The structures are largely bulkheads with fronting concrete rubble or field stone rip-rap used in several cases. The majority of these structures are of timber construction with, in many cases, a backing of galvanized sheeting. Many of the older structures have undergone a considerable amount of repair and rebuilding or are now ineffective.

Beach widths in undeveloped segments of the shoreline are about 65 feet whereas there is little or no beach in many of those areas where effective bulkheads have been constructed.

Off shore conditions are much as described in the south with a gently sloping bottom and well developed off shore sand bars. A single water depth measurement was made in this section and showed that water depth at 50 feet from the shoreline was 1.5 feet.

Sections 8 and 9

Shoreline conditions along the southern third of this coastal segment are much the same as were described immediately to the south. At about Vaness Road, however, the bluffs cut by the ancient glacial lake swing away from the shoreline and between this point and the north section line, the terrace broadens from 1000 feet to 3100 feet. The nature of the bluff also changes near the northern section line. Here, erosion by streams tributary to the Black River has largely destroyed

the sharp bluff that was typical to the south, leaving a relatively gentle dissected slope.

The surface of the terrace in the area immediately north of Vaness Road becomes quite swampy and development for housing is restricted to the immediate shore zone in this region. A housing density of 28 houses per mile has been reported for this section of the shoreline.

Twenty-one structures were described in sections 8 and 9. All of these were either bulkheads or revetments, with bulkheads predominating in the southern portions of the area and revetments or combination bulkhead-revetments most common in the northern segments. In the southern third of the section the beaches range between 15 and 35 feet in width and are mostly sand. From 0.3 to about 0.8 the beaches in undeveloped areas are about 30 feet wide with little or no beach in front of many of the protective structures. From 0.8 to the northern section line there is no beach and the shoreline is a continuous bulkhead-revetment. Conditions off shore remain essentially the same as in the sections to the south with a gentle slope and well developed sand bars. A water depth determination at about 0.5 showed a depth of 1.18 feet at a distance of 50 feet from the shoreline.

A single recession rate measurement was available for this segment of the shoreline. It showed a short term average of 1.7 feet per year.

Section 4

The back shore zone in Section 4 is the Nippissing terrace as was the case to the south. The exact location of the western edge of this terrace is practically impossible to determine, due to erosion of the bluff that would normally mark this boundary by streams tributary to the Black River.

From the south section line to 0.7 there is no beach and the shoreline is marked by a continuous series of bulkheads and revetments. From 0.7 to the northern section line, those areas in which protective structures have been installed also have no beaches. There are, however, a number of undeveloped segments of the shoreline and in these areas beaches of up to 30 feet have

developed. Population density in Section 4 is 45 houses per mile and there were 15 protective structures described along the shoreline in this section. The majority of these structures are bulkheads, originally of timber construction, that have been repaired or rebuilt through the addition of stone or broken concrete behind the original bulkhead. Although these structures are for the most part relatively effective, instances were noted where homes built close to the structures had been structurally damaged through the action of waves topping the bulkheads.

Offshore conditions are still much the same as in the areas to the south with a gently sloping lake bottom and well developed sand bars. At about 0.1 the water depth was found to be 1.2 feet at a distance of 50 feet from the shoreline. A single long term erosion rate was available for Section 4. This shows a 100 year average recession rate of 0.6 feet per year.

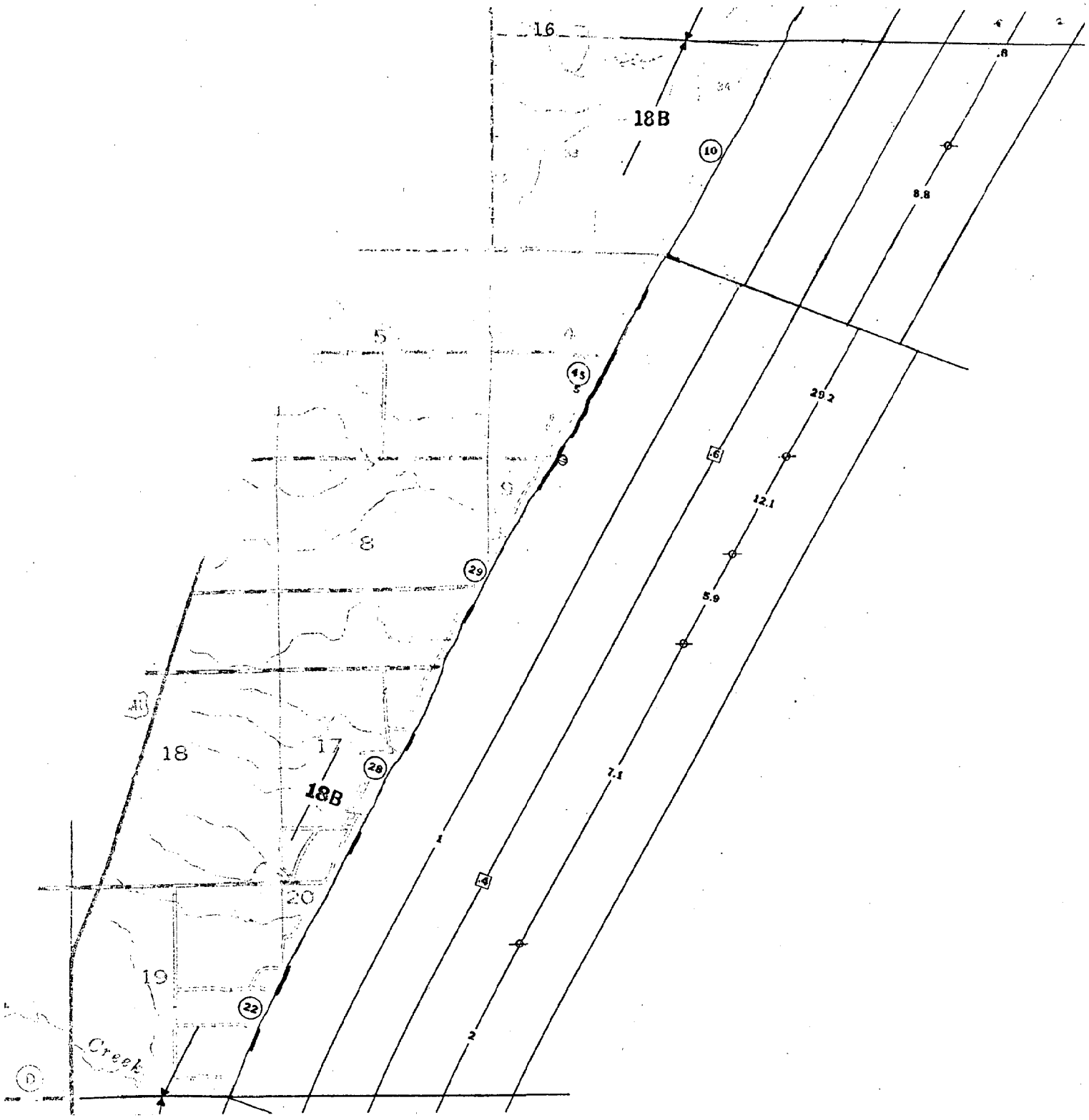
Sections 33 and 34, T.14N.

Although the immediate back shore area through this coastal segment is a continuation of the Nippissing terrace that was traced from the south, the terrace has merged with the flood plain of the Black River and differentiation of the two is very difficult.

From the southern section line of section 33 to about .15, there is little or no beach fronting the protective structures. From .15 to the north line of Section 34, sand beaches of from 15 to 65 feet are present, even in those areas where protective structures have been constructed.

There were 11 structures described in this coastal region, 10 of which were either bulkheads, revetments, or composite structures. The 11th structure consisted of a series of 4 timber crib groins. These groins were almost completely buried in the beach sand with only 1 or 2 feet projecting into the water. Because the shoreline is continuous through this section, it is thought that these structures were buried through a general accretion of

sand in this area of the shoreline and that the groins themselves had little or no effect. Although no recession rate data are available for this immediate location, short term averages are available at both the north and south section lines. Annual average recession rates were 1.7 feet per year at the southern section line and 2.2 feet per year at the northern section line. Housing density along this section of the shoreline is reported as 10 houses per mile. Offshore conditions are essentially the same as to the south with a gently sloping lake bed and well developed offshore sand bars. The water depth 50 feet offshore was less than 2 feet near the north section line and between 2 and 4 feet at a distance of 50 feet from the shoreline at 0.5.



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miles

PUBLIC PERCEPTION: EROSION HAZARDS { 3 Public safety, 2 Property, 1 Environment }

1952 SHORE DAMAGE SURVEY -1=$10,000 (1952)

RECESSION RATES { Long-term-approx 100 yrs. / Short-term-approx. 10 yrs. } (in feet/yr.)

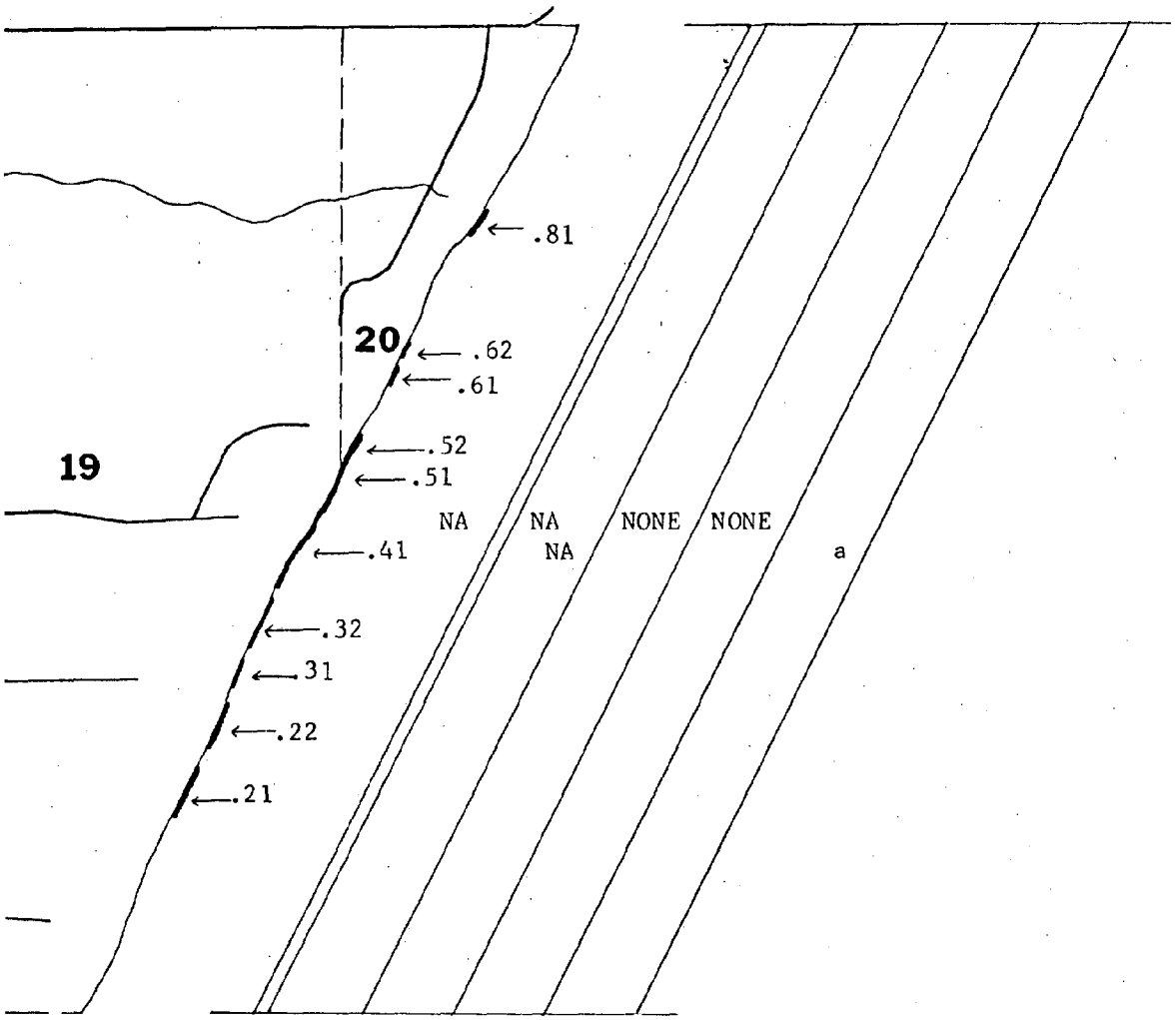
SHORE HEIGHT (in tens of feet)

SHORE PROTECTION STRUCTURES

(33) HOUSES/MILE-Non-urban

BOAT RAMPS

REACH 18B

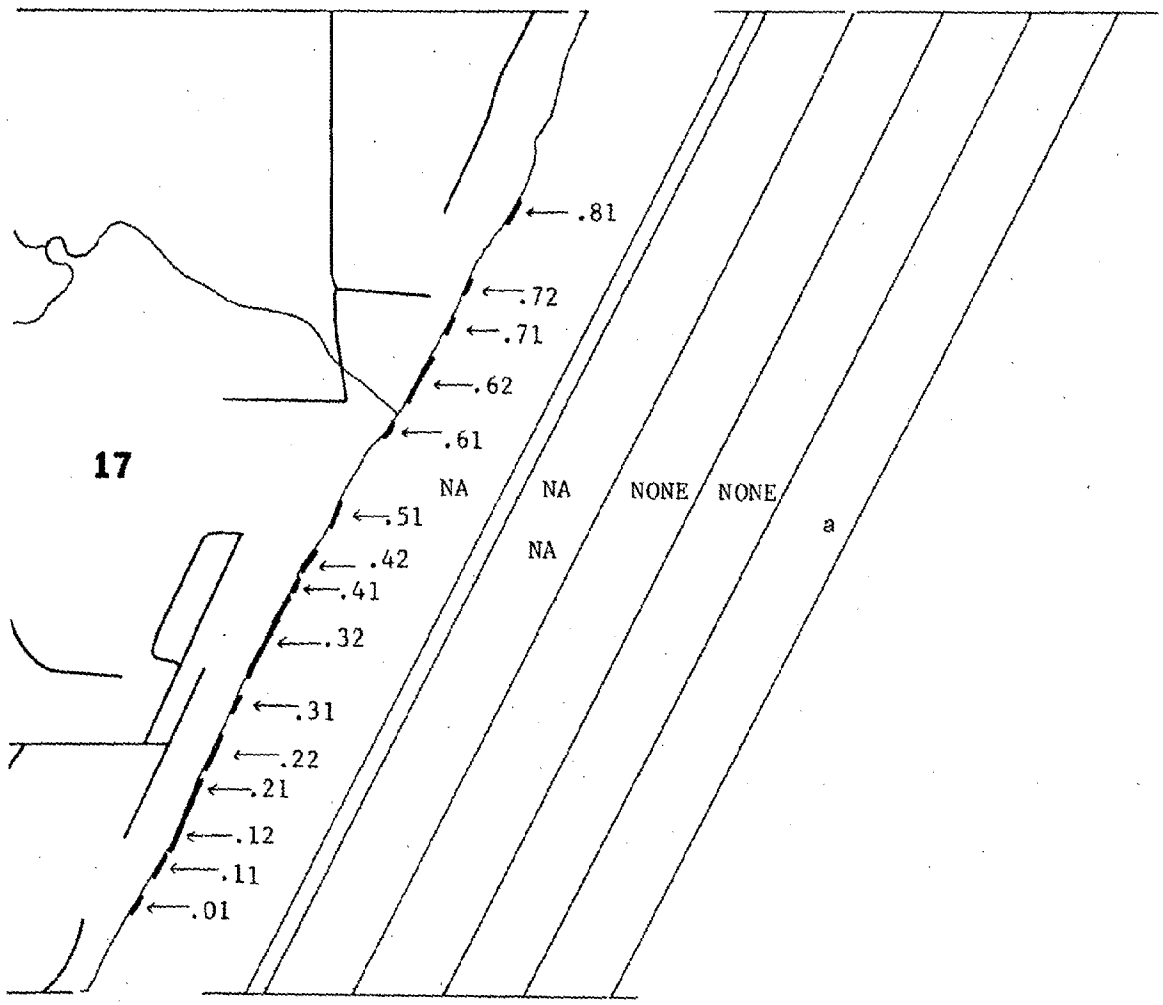


3 E.

SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	none	
2. TOE	none	
3. BEACH	a-10-65 ft. sand	



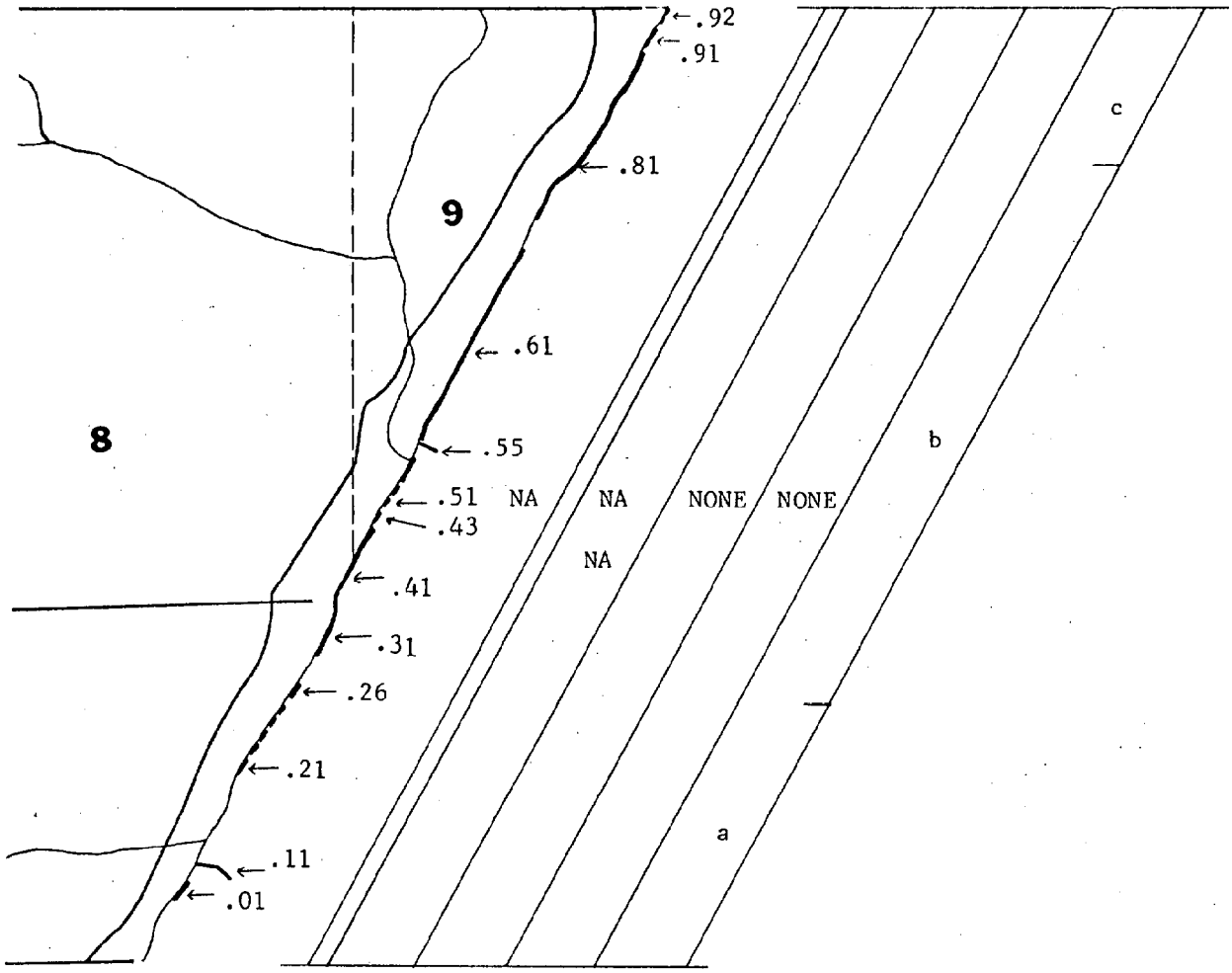
SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	none	
2. TOE	none	
3. BEACH	a-0-65 ft. sand	



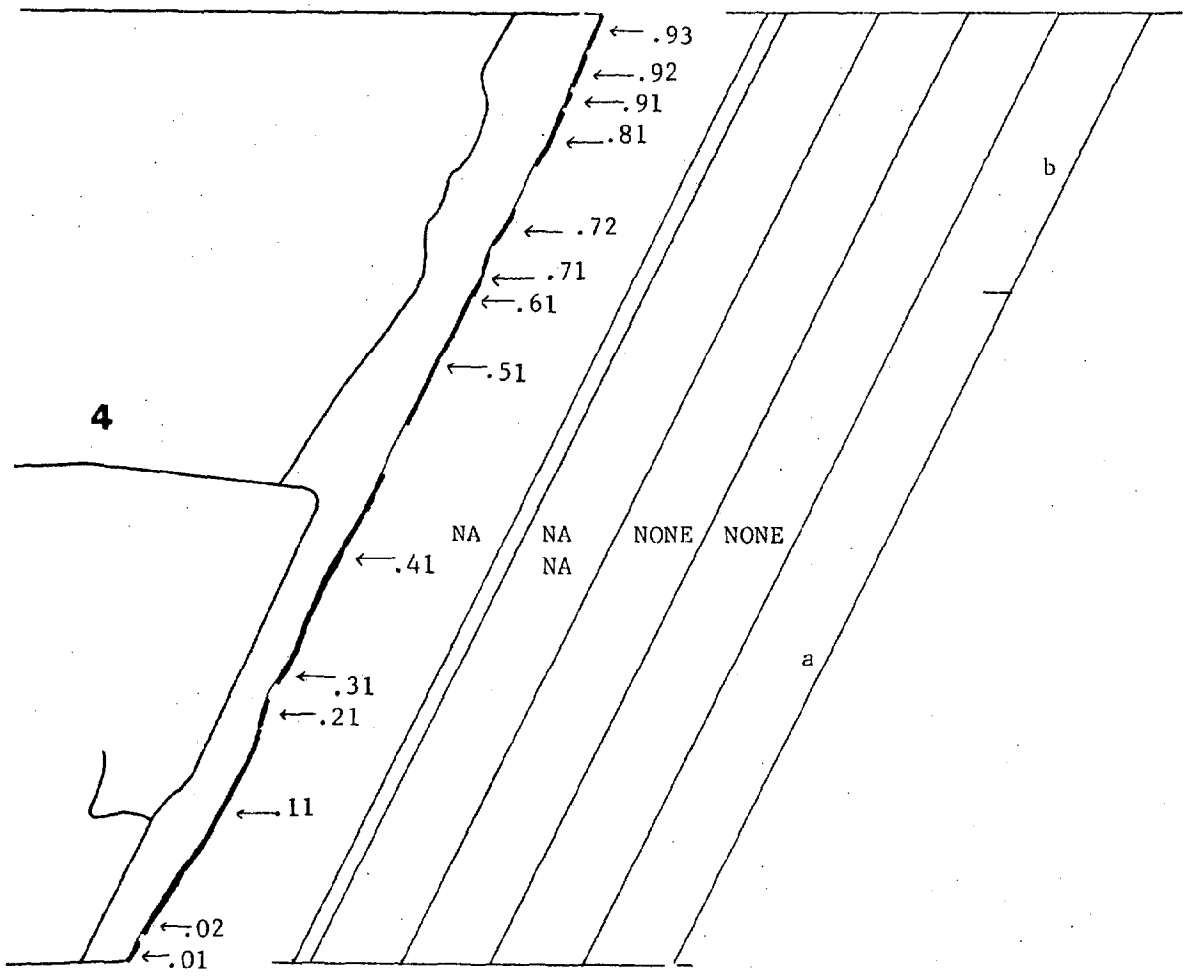
SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no sratigraphy visible (low confidence)

1. BLUFF	none			
2. TOE	none			
3. BEACH	a-15-35 ft. sand	b-0-30 ft. sand	c-no beach	



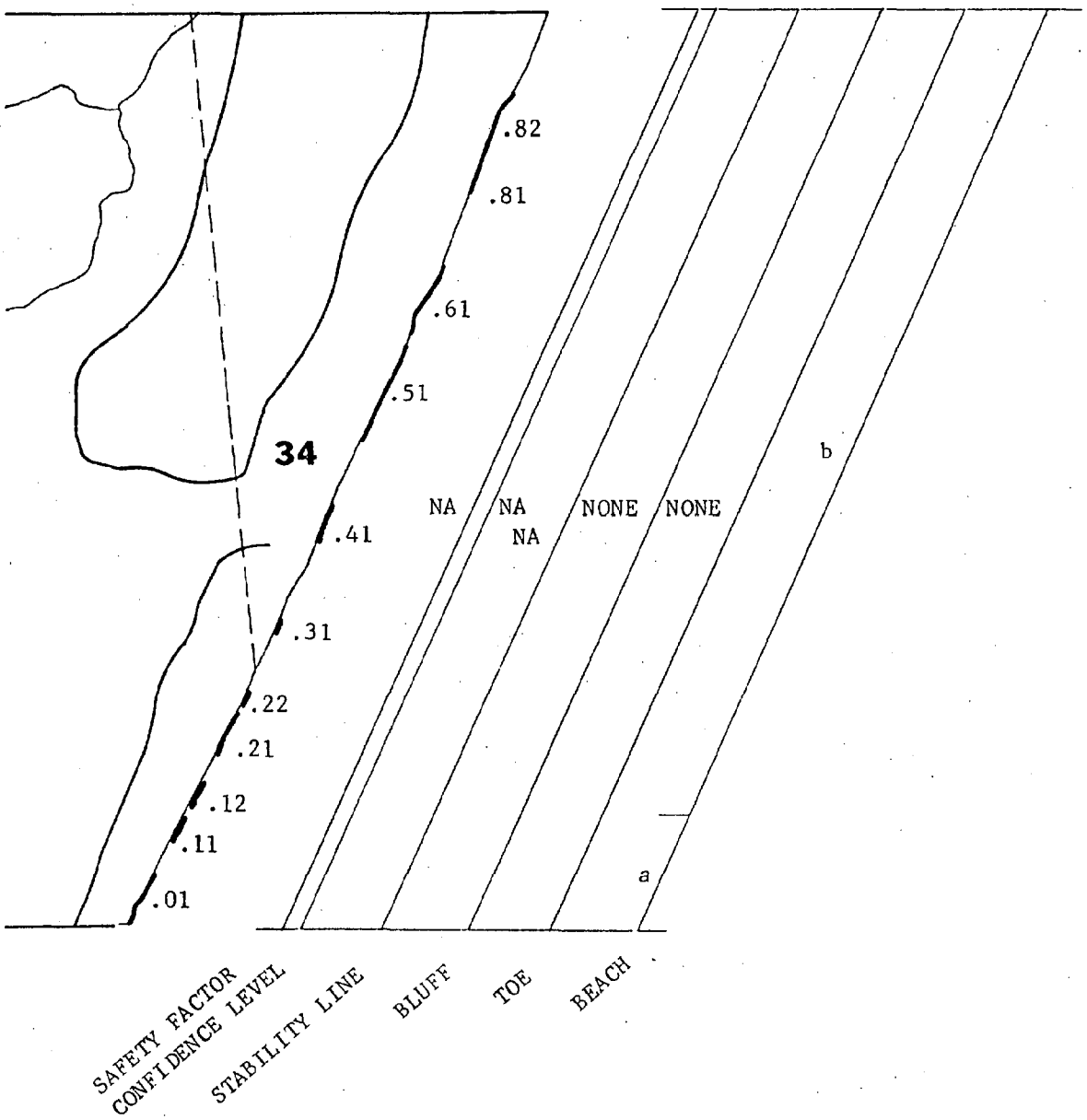
SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	none		
2. TOE	none		
3. BEACH	a-no beach	b-0-40 ft. sand	



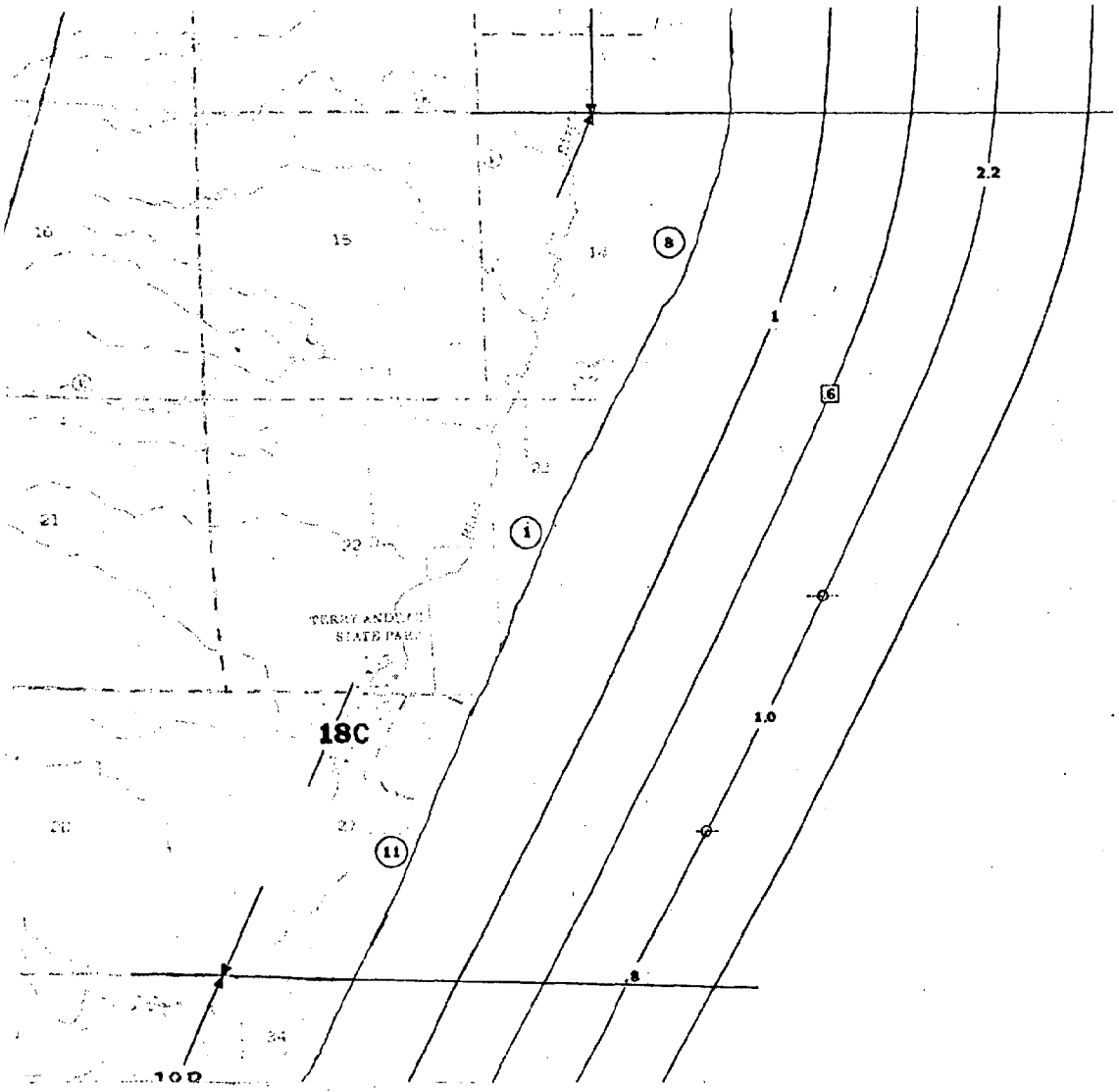
SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	none		
2. TOE	none		
3. BEACH	a-no beach	b-15-65 ft. sand	



N

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miles

Reach 18C

PUBLIC PERCEPTION: EROSION HAZARDS { 3 Public safety / 2 Property / 1 Environment

1952 SHORE DAMAGE SURVEY -1=$10,000 (1952)

RECESSION RATES { 8 Long-term-approx 100 yrs. / Short-term-approx. 10 yrs. } (in feet/yr.)

SHORE HEIGHT (in tens of feet)

SHORE PROTECTION STRUCTURES

(23) - - - - - - - - - - - - - HOUSES/MILE-Non-urban

9 - - - - - - - - - - - - - BOAT RAMPS

FIELD REPORT - REACH 18C

Location and General Description

Reach 18C extends for a distance of 3 miles and consists of the shoreline along sections 27, 22, and 14, T.14N., R.23E. The reach has an overall priority rating of 24, and ranks ninth out of the twelve reaches north of Ozaukee County. This low ranking is primarily due to the fact that a large proportion of the shoreline within the reach is incorporated in the Terry Andrae - Kohler State Park complex. As a result there are only 20 private dwellings along the shoreline of the total reach, leaving much of this reach completely undeveloped and essentially in its natural state.

In contrast to the more highly developed area immediately to the south in 18B, the beaches in Reach 18C are relatively wide, ranging up to 100 feet in width. The back shore area consists primarily of terrace sands. In some areas sand dunes in excess of 30 feet high have developed. Erosion behind the beaches has produced cut faces in many areas which, when present, are normally between 10 and 15 feet high.

As was the case in Reach 18B to the south, the ancient bluffs marking the western limit of the terrace have been largely destroyed by the erosion of streams tributary to the Black River.

The principal mechanism of erosion throughout this reach is the removal of easily eroded sands through the action of storm waves. Ten year erosion averages were determined at two stations within the reach, and values of 2.2 feet/year and 1.4 feet/year were obtained. A single hundred year measurement was made within the reach, giving a value of 0.6 foot/year.

Section 27

The beaches in this section are well developed and range from 20 to 100 feet in width. These beaches consist primarily of sand although they do have an appreciably higher pebble content than in Reaches 18A and B to the south.

The section is relatively lightly developed, having a housing density of 10 houses per mile. All houses are confined to the southern half of the section since the northern half of the section is incorporated into the Terry Andrae - Kohler State Park complex. Only one structure was described in this section. This structure was a short bulkhead at the end of the parking lot in the state park. There was one short term recession rate measurement available; a rate of 1.4 feet per year was measured near the northern section boundary. Offshore conditions remain much the same as in the reaches to the south with gently sloping bottom and well developed bars. A single depth measurement was made at about 0.9. The water depth 50 feet from the shore was found to be between 2 and 3 feet. However, this measurement was made on the flanks of a sand bar and depths as great as 4 feet occur between this point and the shore.

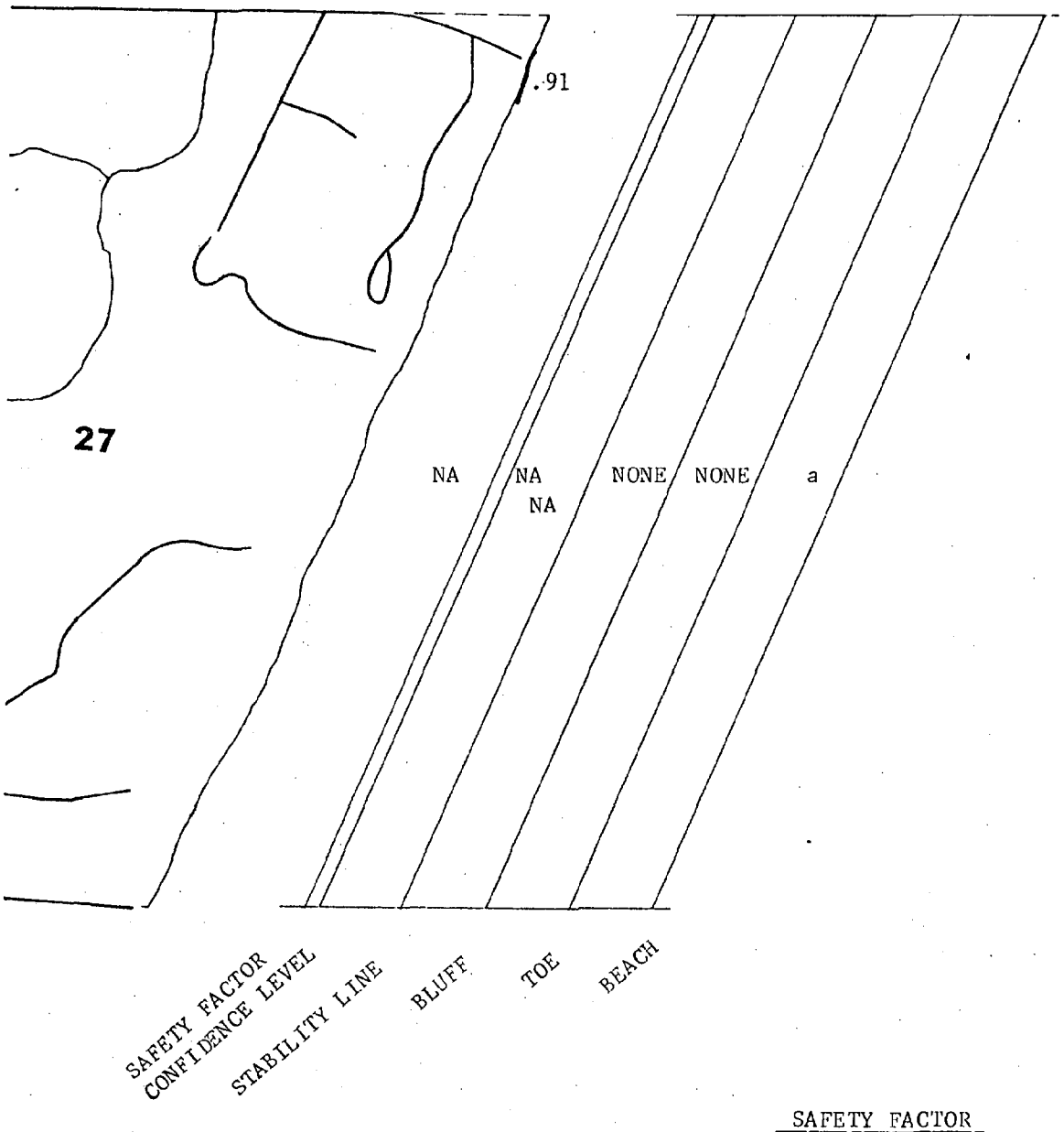
Section 22 and 23

This segment of coast, which lies within the state park complex, is almost completely undeveloped. It has a listed housing density of 1 house/mile and no protective structures. Sand beaches range in width from 5 to 30 feet and the back shore is made up primarily of dune sands. Modern shoreline erosion has cut faces of up to 15 feet into these dunes. No recession rate data is available for this section. Due to water conditions at the time this section was investigated no water depths were obtained.

Section 14

Except for some construction at Camp Taswood in the immediate vicinity of the southern section line, this section is also undeveloped. Sand beaches range in width from 5 to 40 feet. The back shore area is made up primarily of sand dunes and no protective structures were described. The housing density was given as 8 houses/mile. Recession rate data was available at one point

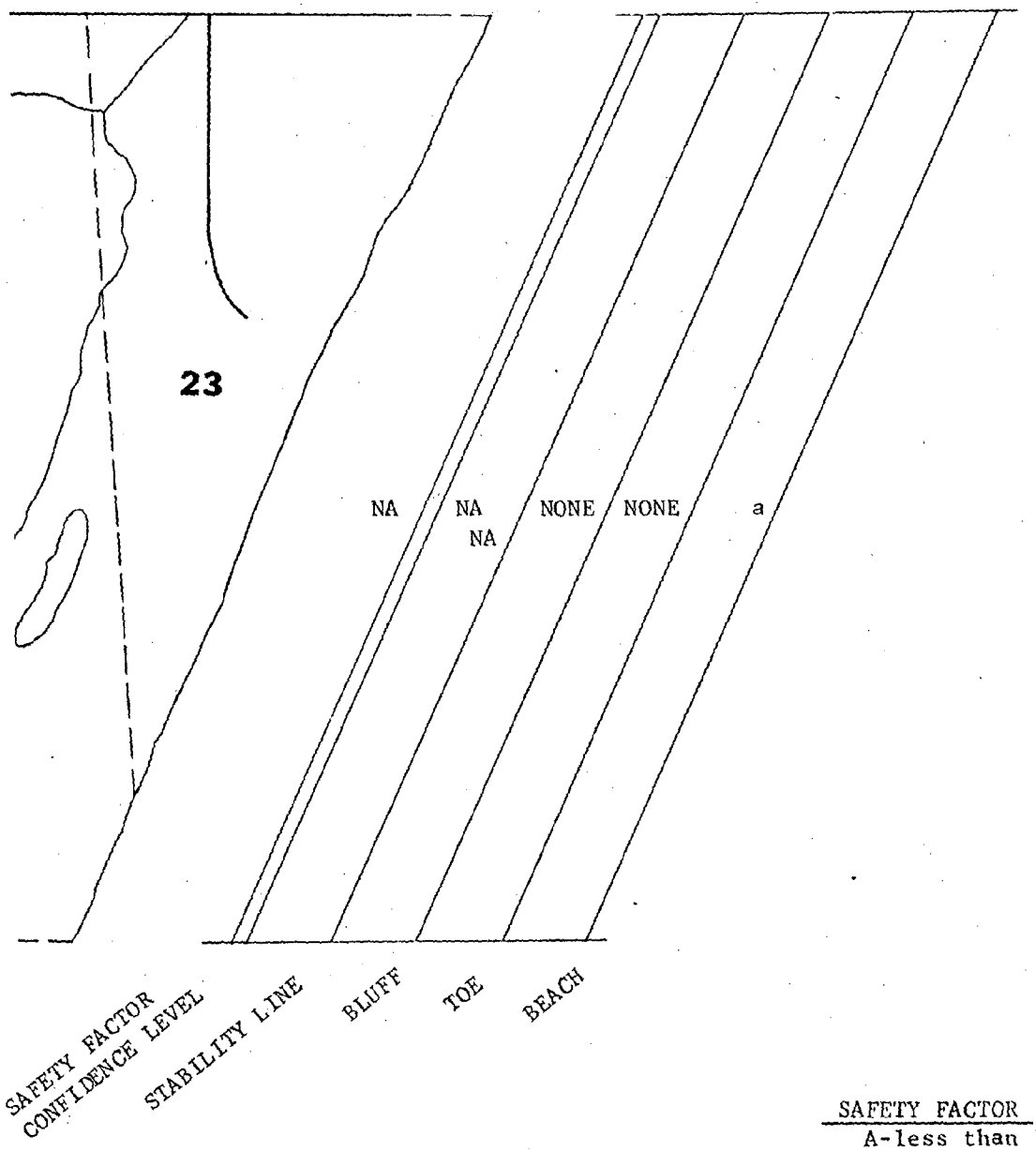
near the southern section line and yielded the value of 0.6 foot/year. Offshore conditions remain essentially the same as in the sections to the south. A depth measurement was taken at 0.5 and the water was found to be 2 feet deep at a distance of 50 feet from the shoreline.



SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	none	
2. TOE	none	
3. BEACH	a-20-100 ft. sand	



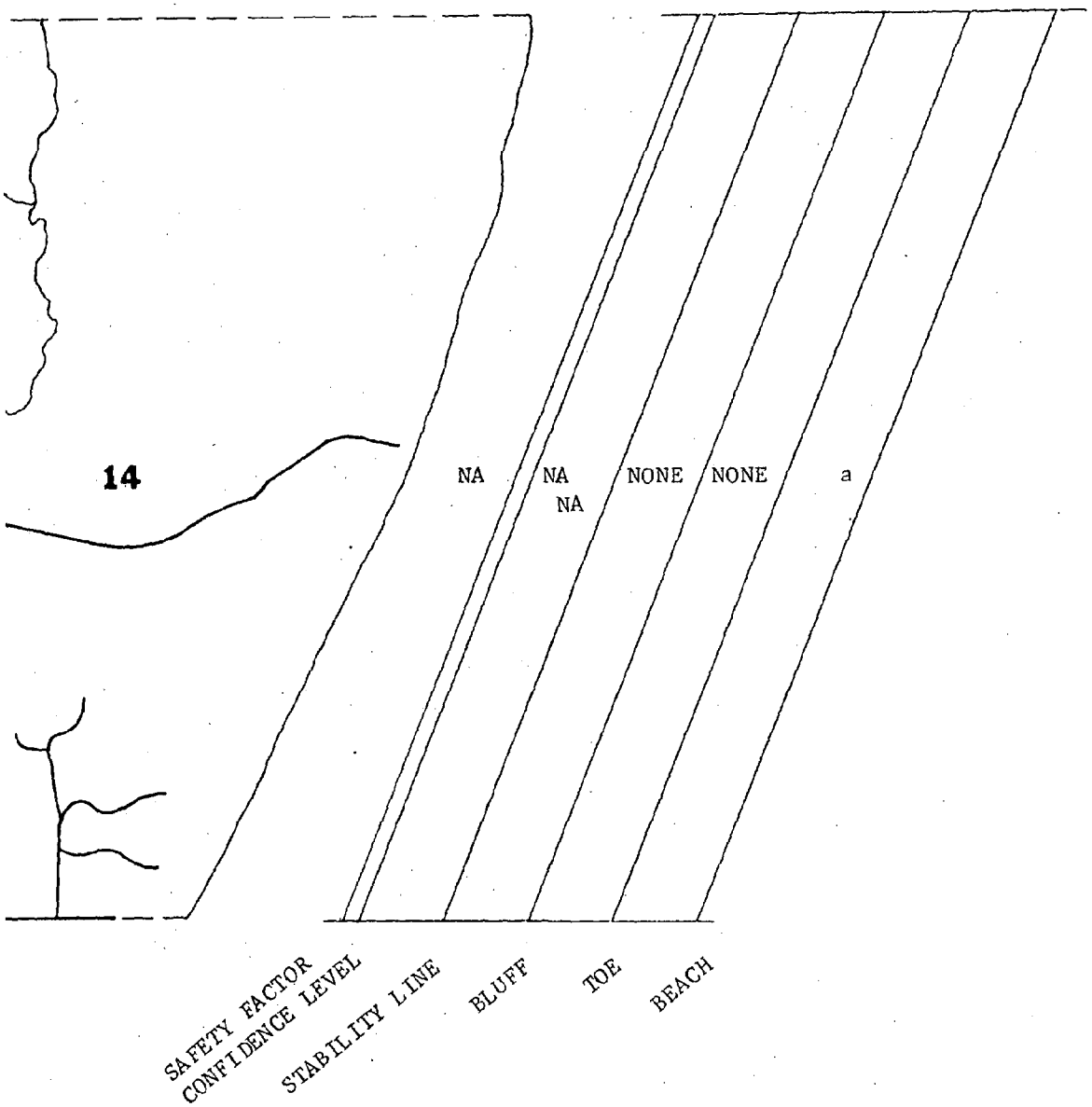
SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	none	
2. TOE	none	
3. BEACH	a-5-30 ft. sand	



SAFETY FACTOR
- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL
- A-boreholes (high confidence)
- B-near boreholes stratigraphy visible
- C-no stratigraphy visible (low confidence)

1. BLUFF	none	
2. TOE	none	
3. BEACH	a-5-40 ft. sand	

FIELD REPORT - REACH 19

Location and General Description

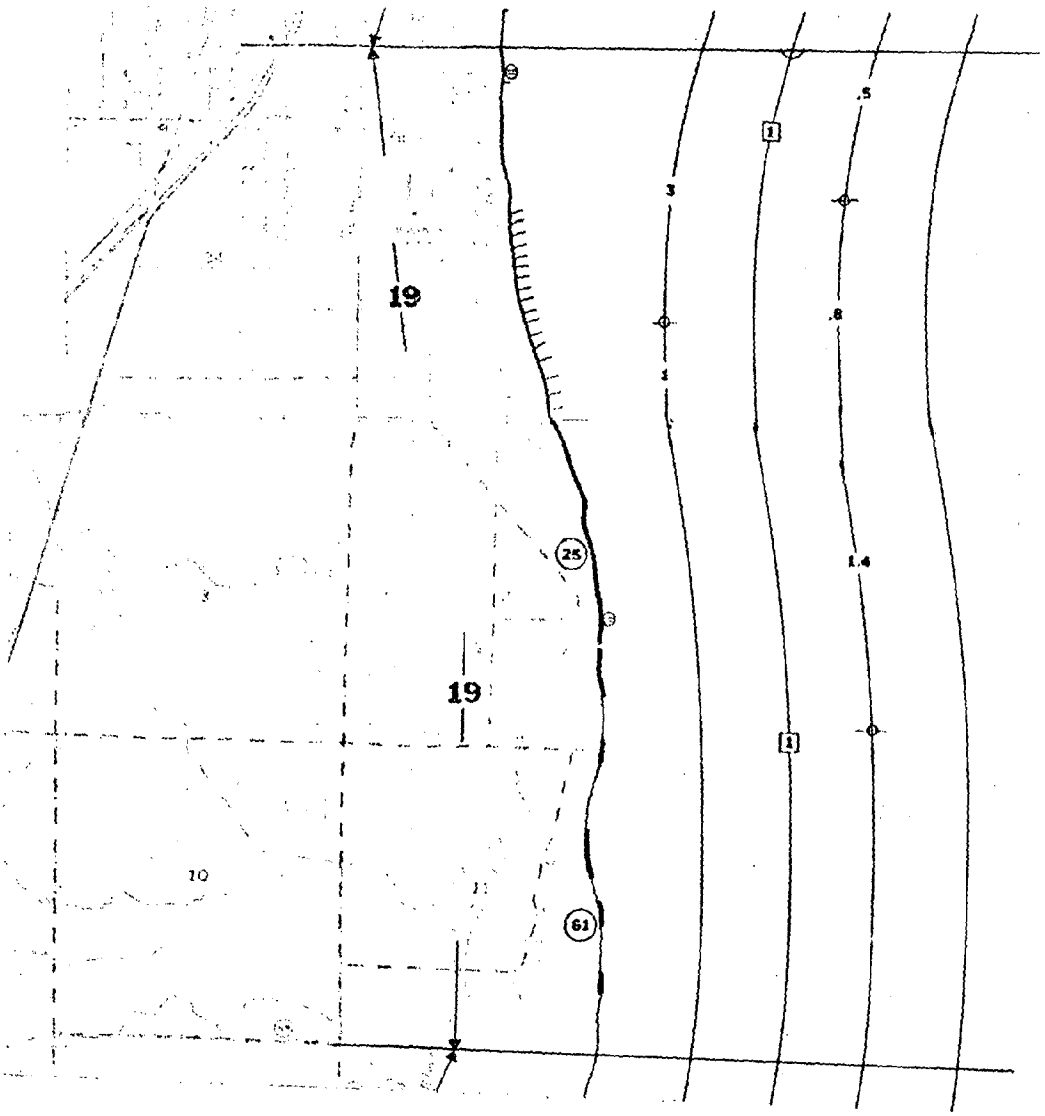
Reach 19 is a little over 2 miles long in a north-south direction and includes the shoreline along Sections 11 and 2 of T.14N., R.23E., and of Section 35 and a portion of Section 26 of T.15N., R.23E. The reach has a priority of 19, making it the 5th highest ranking reach in the Sheboygan-Manitowoc study area.

This reach is a zone of transition in terms of geology, geomorphology and in its land use. The southern portions of the reach are a continuation of the terrace that extends southward almost to Port Washington. Northern portions of the reach are in an area of moderately high bluffs, typical of much of the area north of Sheboygan.

In terms of land usage, the southern portion of the area is one of year round beach residences, fronted by a moderately wide sand beach. In the central portion of the reach this residential area gives way to the grounds of the Edgewood Power Plant and the sewage disposal facilities for the City of Sheboygan. Immediately north of the sewage plant the land is largely urban in character, consisting of roughly a quarter mile of park lands which give way to closely spaced urban housing on top of the bluff.

Section 11

The shoreline in this section lies along the broad flat that is a combination of the Nippissing terrace and the flood plain of the Black River. The back shore area consists of beach and dune sands. Beaches are well developed, and for the most part, relatively wide. Beach widths show a range of 5 to 65 feet but the narrower beaches are of very limited extent.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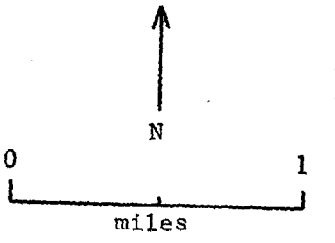
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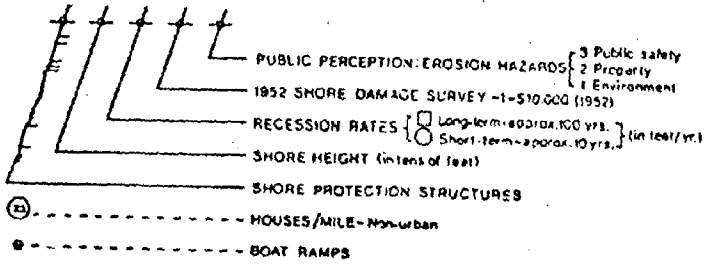
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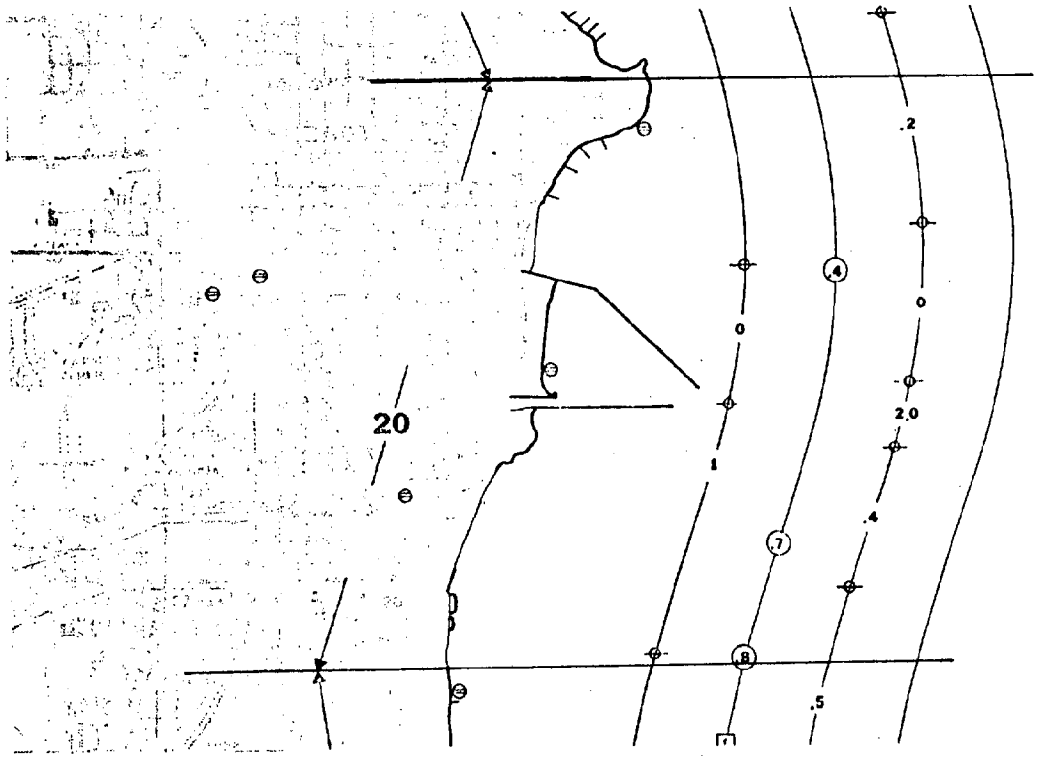
3 Public safety
2 Property
1 Environment
1952 SHORE DAMAGE SURVEY -1=$10,000 (1952)
RECESSION RATES
Long-term - approx. 100 yrs.
Short-term - approx. 10 yrs.
(in feet/yr.)
SHORE HEIGHT (in tens of feet)
SHORE PROTECTION STRUCTURES
HOUSES/MILE - Non-urban
BOAT RAMPS

REACH 19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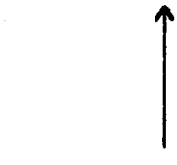
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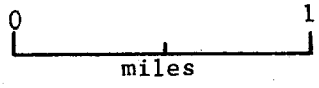
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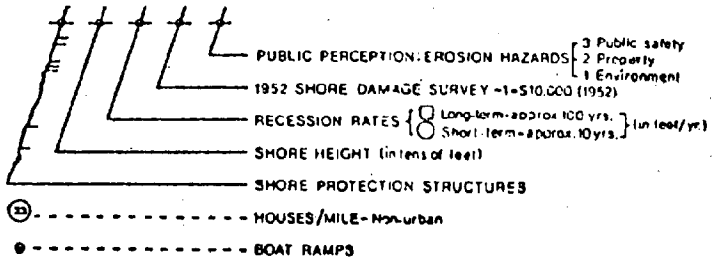
1
miles

Reach 20


PUBLIC PERCEPTION: EROSION HAZARDS
3 Public safety
2 Property
1 Environment
1952 SHORE DAMAGE SURVEY -1=$10,000 (1952)
RECESSION RATES
Long-term-approx 100 yrs.
Short-term-approx. 10 yrs.
(in feet/yr.)
SHORE HEIGHT (in tens of feet)
SHORE PROTECTION STRUCTURES
HOUSES/MILE-Non-urban
BOAT RAMPS

Offshore conditions differ somewhat from the sections to the south in that considerable segments of the shoreline have no offshore sand bars and even where bars are present, they are less well developed and fewer in number than was the situation in Reaches 18A, B, and C.

The section is highly developed, having a housing density of 61 houses per mile. Much of this development is, however, in the back shore area and the frequency of homes along the shoreline is roughly comparable to that observed in some of the more highly developed sections of Reach 18B.

Six structures were described along this section. Most of these were light bulkheads fronted with moderately large dolomite blocks.

A single short term recession rate was available for this section, giving an average rate of 2.5 feet/year.

Section 2

This section marks the probable northern terminus of the Nippissing terrace that stretches to the south almost to Port Washington in Ozaukee County. The most probably location of the terminus is the mouth of the Black River which empties into the lake at about 0.35.

Beaches are largely absent throughout this section with most of the shoreline being protected by well constructed groins and bulkheads. Pockets of beaches do occur between the protective structures, but for the most part are no greater than 5 feet in width. South of the mouth of the Black River, erosion has created a low sandy bluff in dune sands. North of the river the land surface begins to rise and at the north section line a 20 foot bluff has been cut in lacustrine silts and clayey silts.

Section 35, T.15N.

From a height of roughly 20 feet at the south section line the bluffs in this section rise to a height of approximately 50 feet at about 0.8. North of this point the bluff drops rapidly into the valley of the Sheboygan River. Shoreline erosion

has cut steep bluffs over all of the relatively high bluff areas of this section. However, exposures are extremely rare along these bluffs due to the large quantities of fill that have been dumped over the edge of the bluff. In addition, the bluffs are for the most part fully vegetated. Profile #1, which was taken about 250 feet north of the south section line, was in one of the few areas in which the stratigraphy of the bluffs was exposed and showed roughly 20 feet of clayey silts underlain by about 1 foot of a reddish brown till. This is the most southerly exposure of till along the Lake Michigan shoreline in Sheboygan County. Scattered exposures along the bluff top indicate a lacustrine sand overlying the clayey silt north of Profile #1 and this was confirmed in boring GT-11. This boring, which is located in close proximity to the edge of the bluff at about 0.75, shows the bluff at this point to be made up of about 19 feet of sand over about 12 feet of clayey silt, over about 9 feet of reddish brown till, over lacustrine sand.

Land use in the section is varied. The City of Sheboygan sewage disposal plant occupies the lakefront from the south section line to about 0.1. The area from the northern limits of the plant to about 0.3 is in park land and most of the remainder of the section is in closely spaced urban housing. A narrow strip of parkway separates the top of the bluff from the residential area from about 0.6 to 0.9. From this point northward the land appears to be municipally owned, being primarily in park land, boat ramps and beaches.

The shoreline from the south section line to about 0.95 is protected by a continuous revetment of large dolomite quarry stone. The area between the revetment and the bluff is filled with a coarse granular fill. A series of 17 permeable groins spaced at about 300 foot intervals extends northward from the south section line. Most of these groins, but not all, are tied to the revetment. When inspected it appeared that these groins were largely ineffective. Little if any beach had been accreted behind the groins and in a number of instances the groins had been flanked and isolated from the revetments to the rear.

Water depths were measured at Profile #1 near the southern section line and at Profile #2 which was taken at the boring site. At Profile #1 it was found to be 72 feet from the shore line to a point at which the water was 5 feet deep. At Profile #2 the 5 foot depth occurred 50 feet offshore. Sand bars were prominent in the northern portion of the section, but were apparently badly disrupted by turbulence created by the groin field in the southern two-thirds of this section.

One long term recession rate observation was available in the section. This measurement, which was made at about 0.8, showed a long term average recession rate of 1 foot/year.

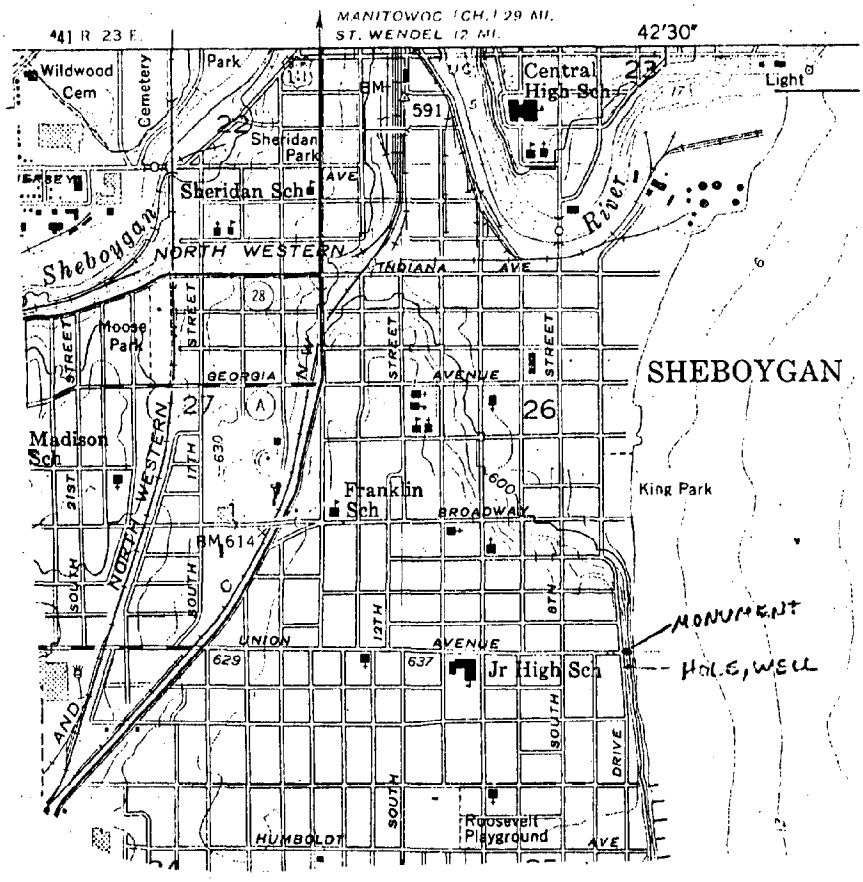
University of Wisconsin--Extension
Geological and Natural History Survey
1815 University Avenue, Madison, Wisconsin 53703

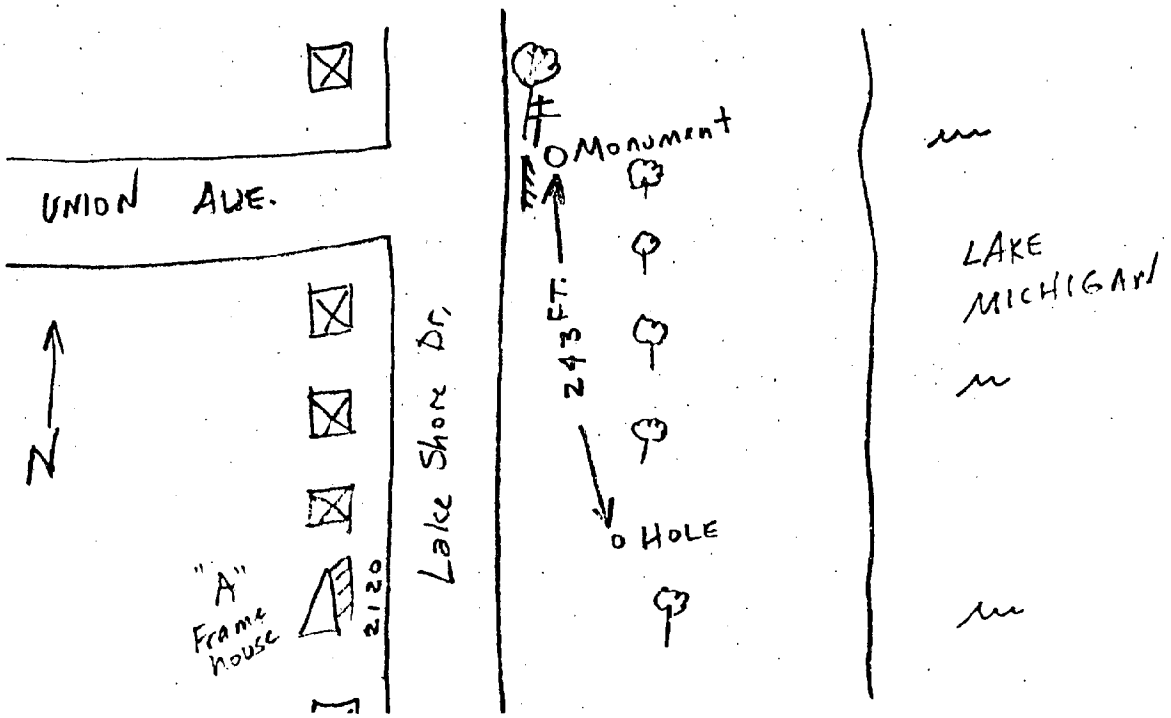
LOCATION AND MONUMENTATION SKETCHES

Boring No. GT-11, Sheboygan South Quad, Sheboygan Co.

Date NE¼/NE¼/ 11 W¼/Sec. 35/ T. 15 N/R 23 E

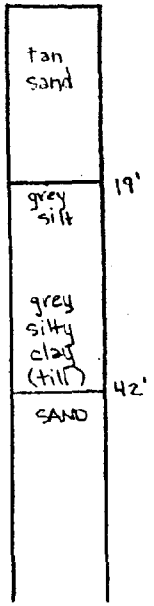
Drawn by

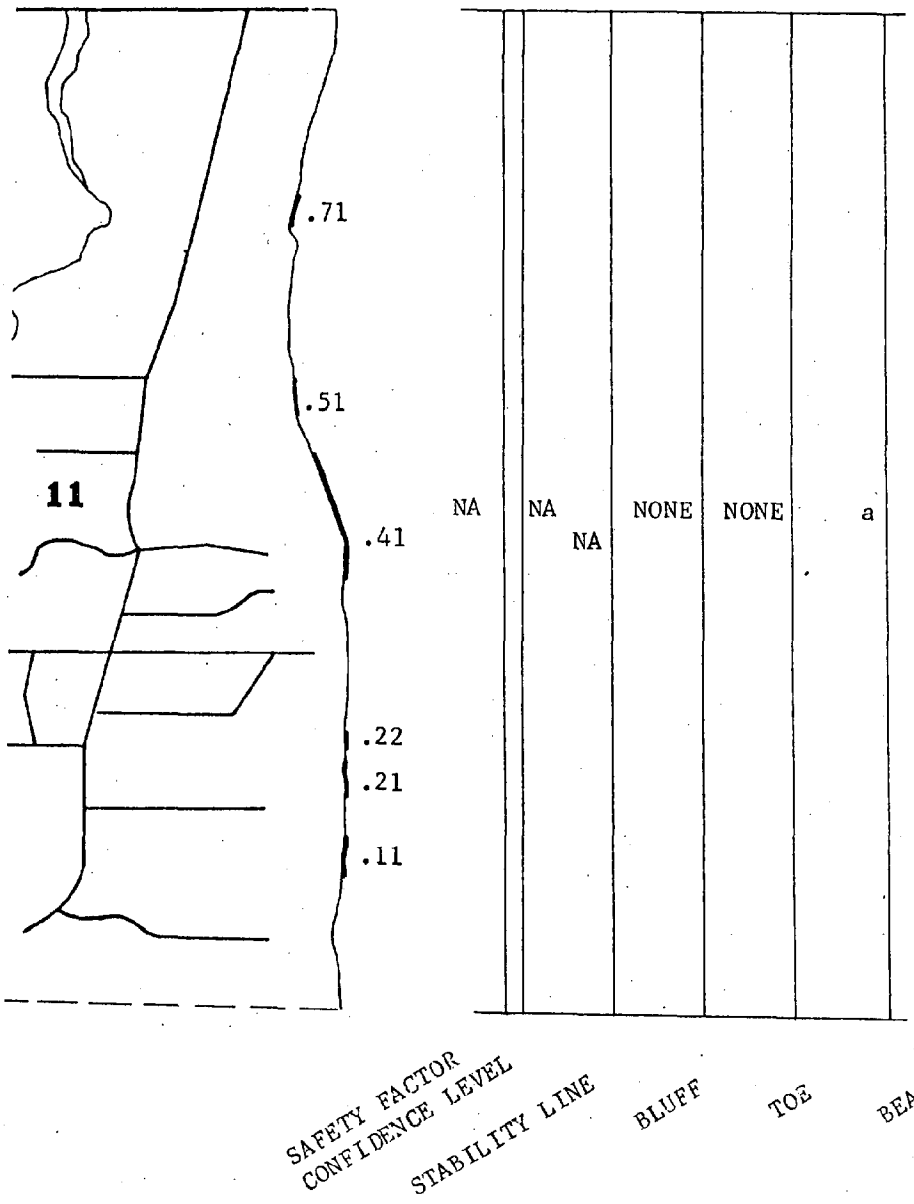




Borehole: GT-11 Location: So. Sheboygan, Sheboygan County, Sec. 35, T15N

Depth (feet)	Blow Counts (split spoon) Standard Penetration 10 20 30 40 50 60 70 80 90 100	Pocket Penetrometer 10 20 30 40 50	w_n %	γ_d (psf)	w_L %	I_P %	% Clay	% Clay & Silt	$\phi°$	c (psf)	c vane (psf)	USCS class.
5			3.3		(sand)			3.4				SP
10												
15			17.7	110	(sand)			35.7	39.7	0		SW
20					(non-plastic silt)			92.3				ML
25					38.5	21.1						
30	no split spoon samples possible											
35					43.8	23.2						CL
40					31.5	15.8						
45							3.0	36.5				SP
50					21.1	7.3	16.5	88.4 ← Possible slump material				
55												
60								27.0				



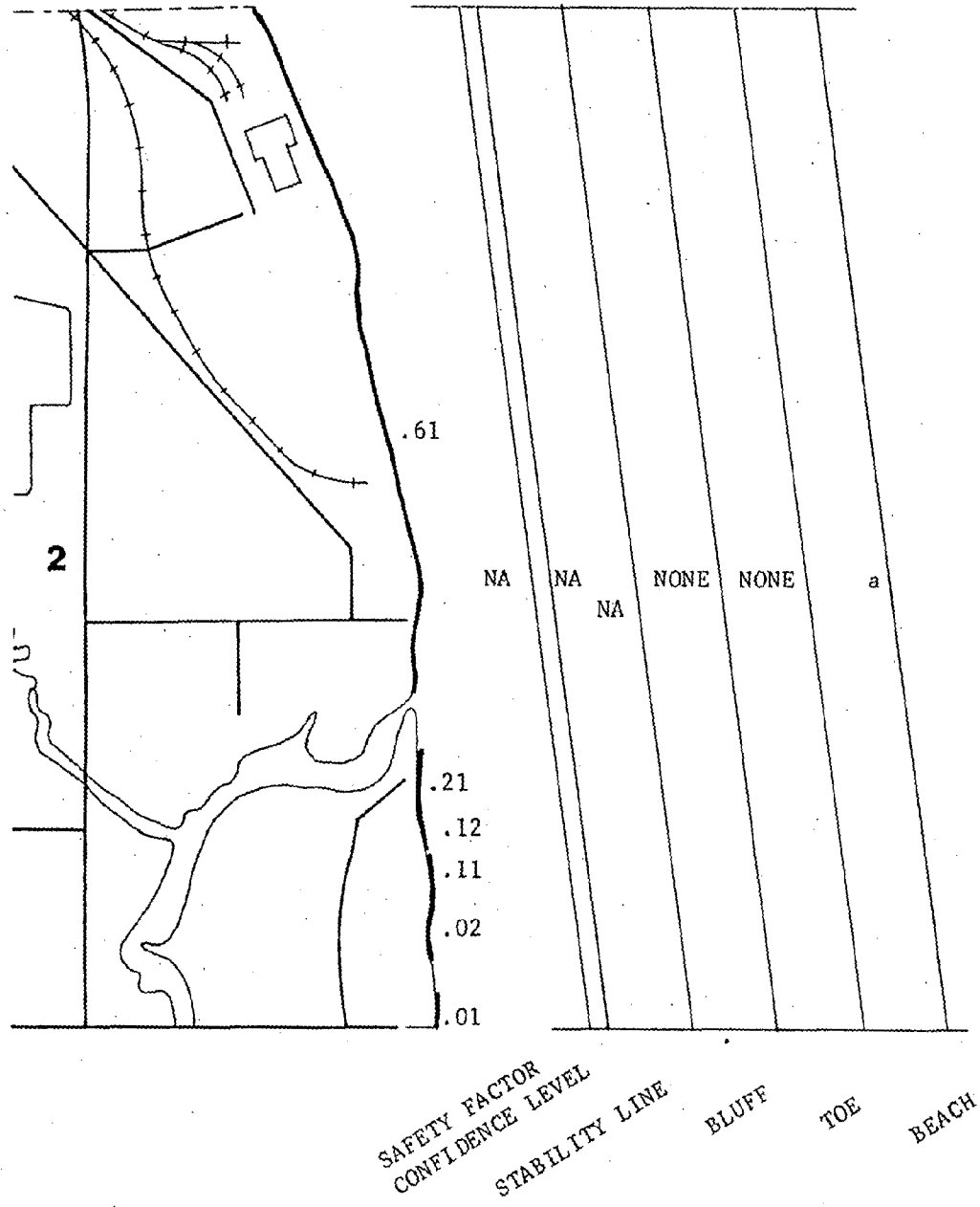


SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	none	
2. TOE	none	
3. BEACH	a-5-65 ft. sand	

T.14N.,R.23E.,Sec.2



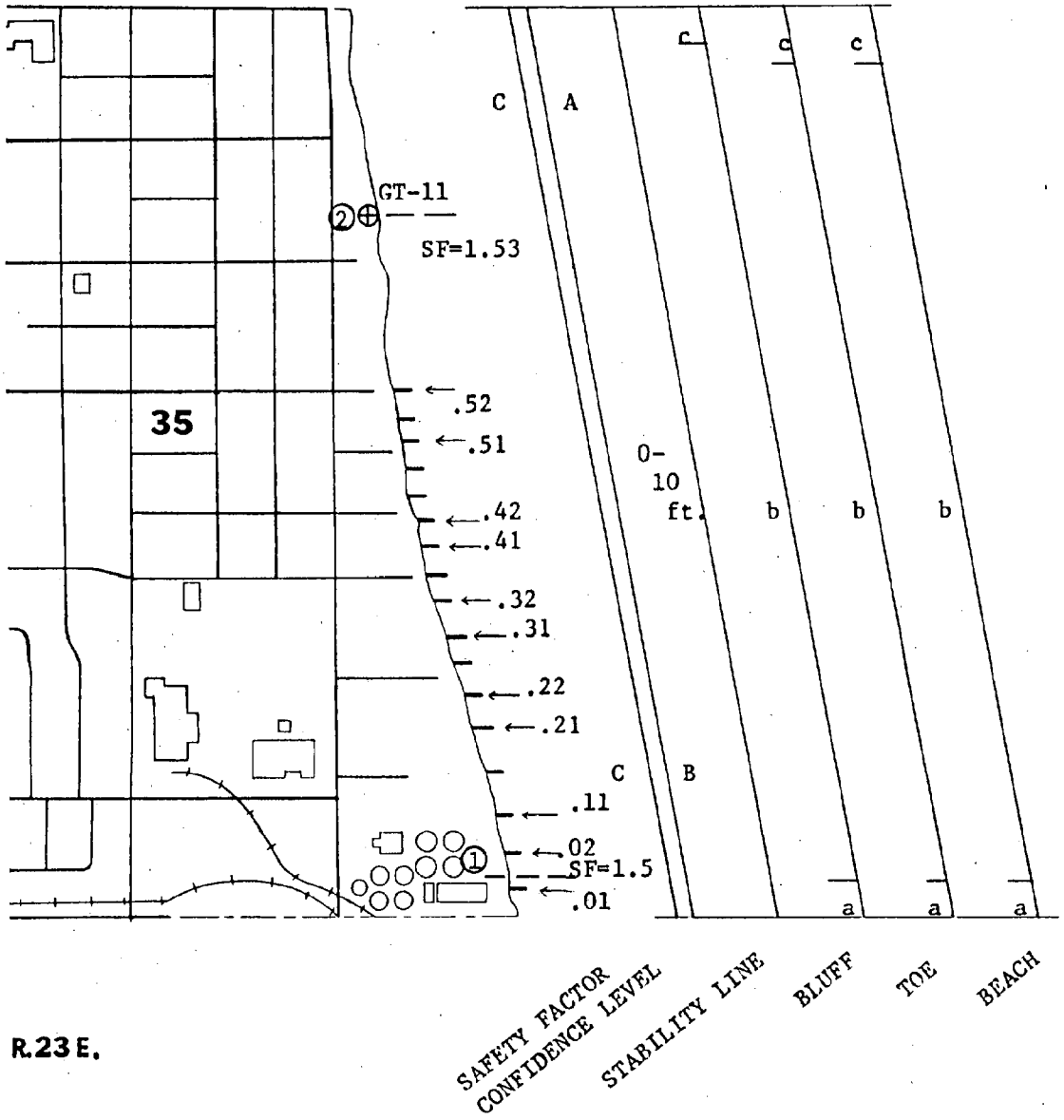
SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	none	
2. TOE	none	
3. BEACH	a-0-5 ft. sand (no beach along most of section)	



SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

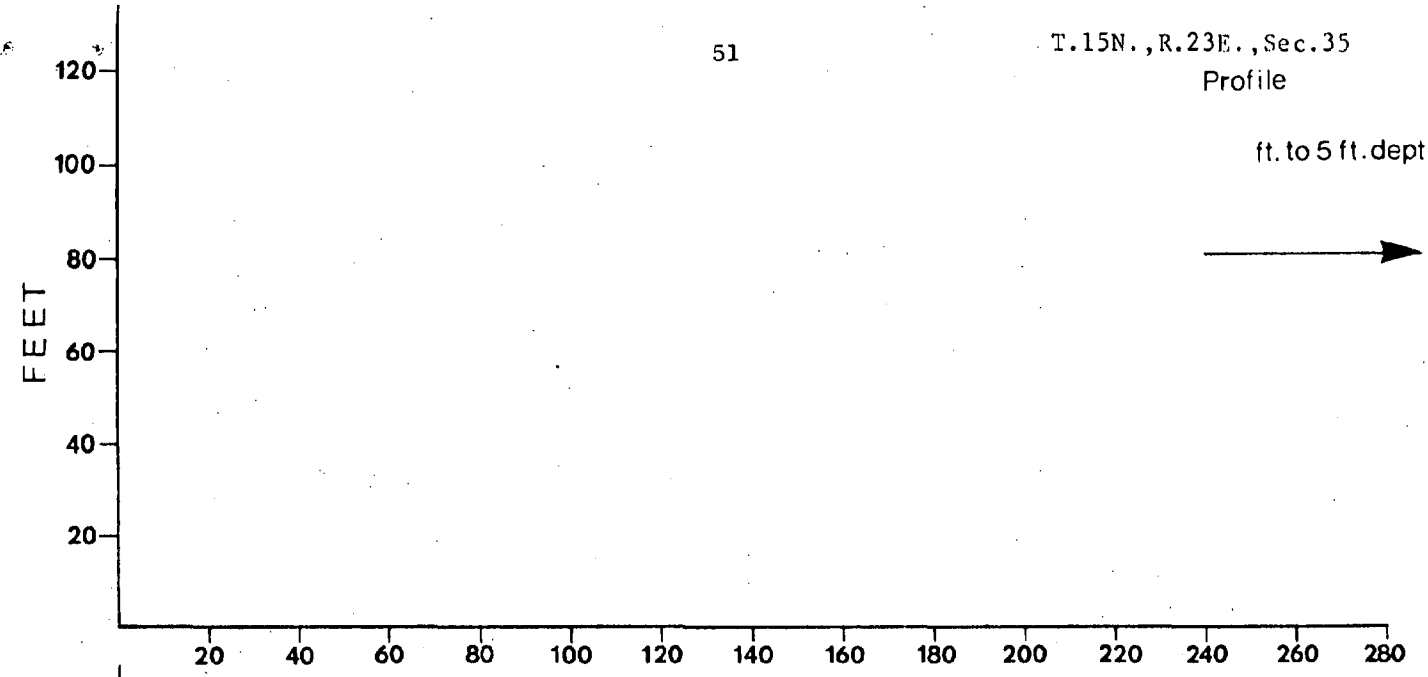
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	a-15-20 ft. bluff, 25% vegetated, actively eroding.	b-20-50 ft. bluff, surface almost totally obscured by fill, fully vegetated except in areas of recent fill and at recent slumped zone at boring GT-11	c-gentle graded and sodded slopes behind beach	
2. TOE	a-stiff, red-brown silty clay till	b-stone revetment, coarse granular fill behind	c-gentle sodded slopes behind beach	
3. BEACH	a-0-30 ft. sand beach	b-no beach	c-15-75 ft. sand beach	
4.STRUCTURES-stone revetment with ineffective permeable groins (numbers 1-17) along southern 2/3 of the section				

T.15N.,R.23E.,Sec.35

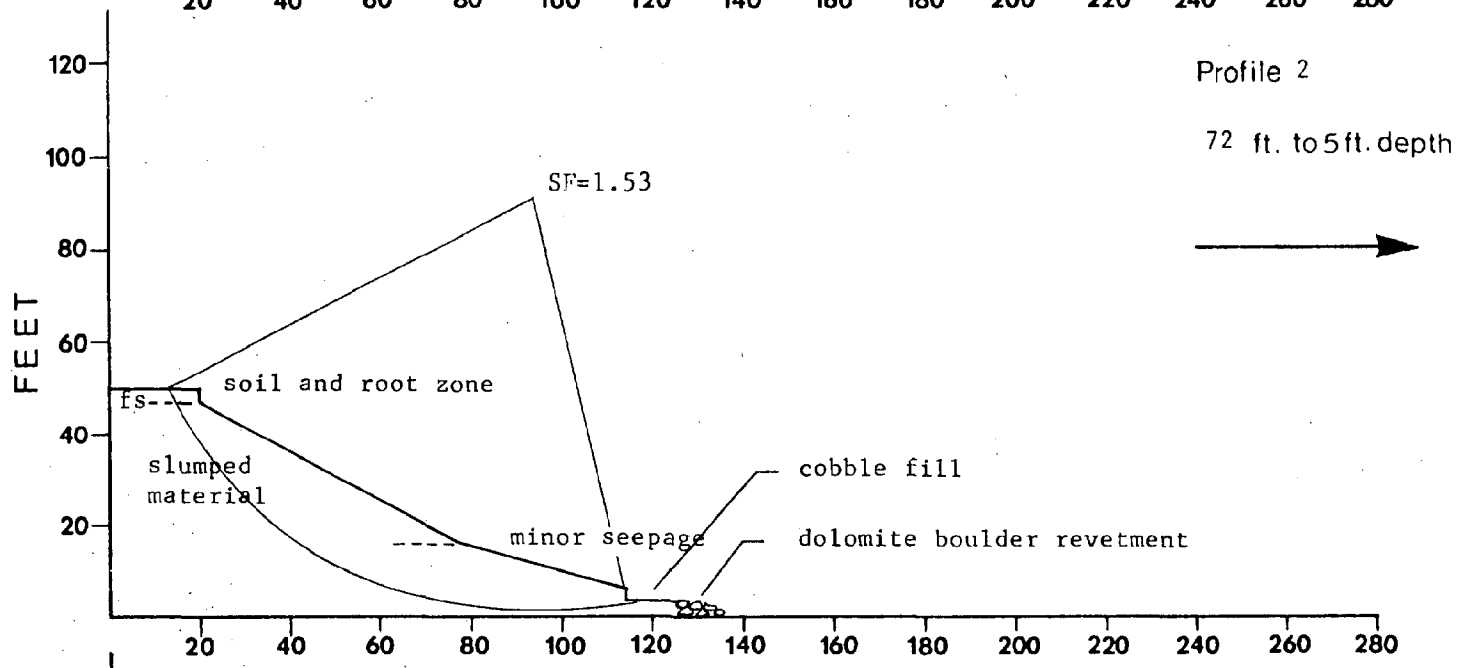
Profile

ft. to 5 ft. depth



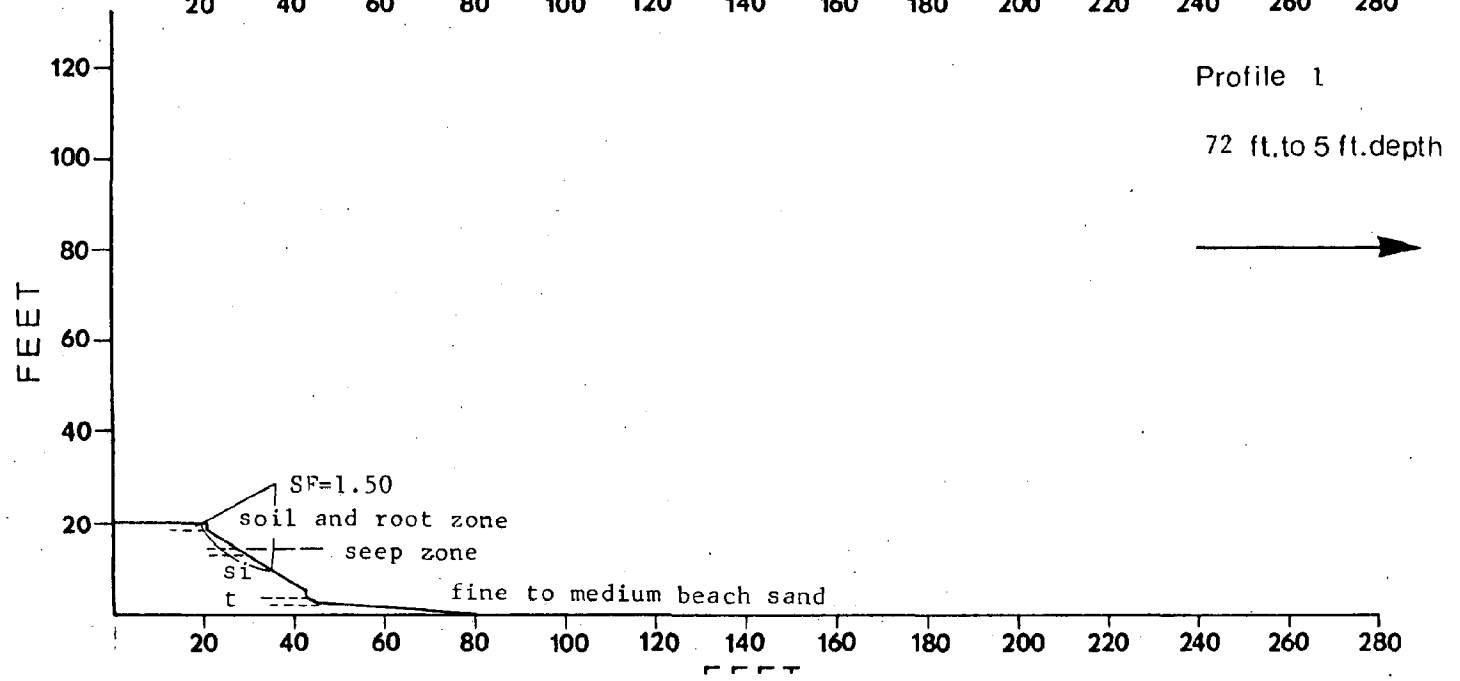
Profile 2

72 ft. to 5 ft. depth

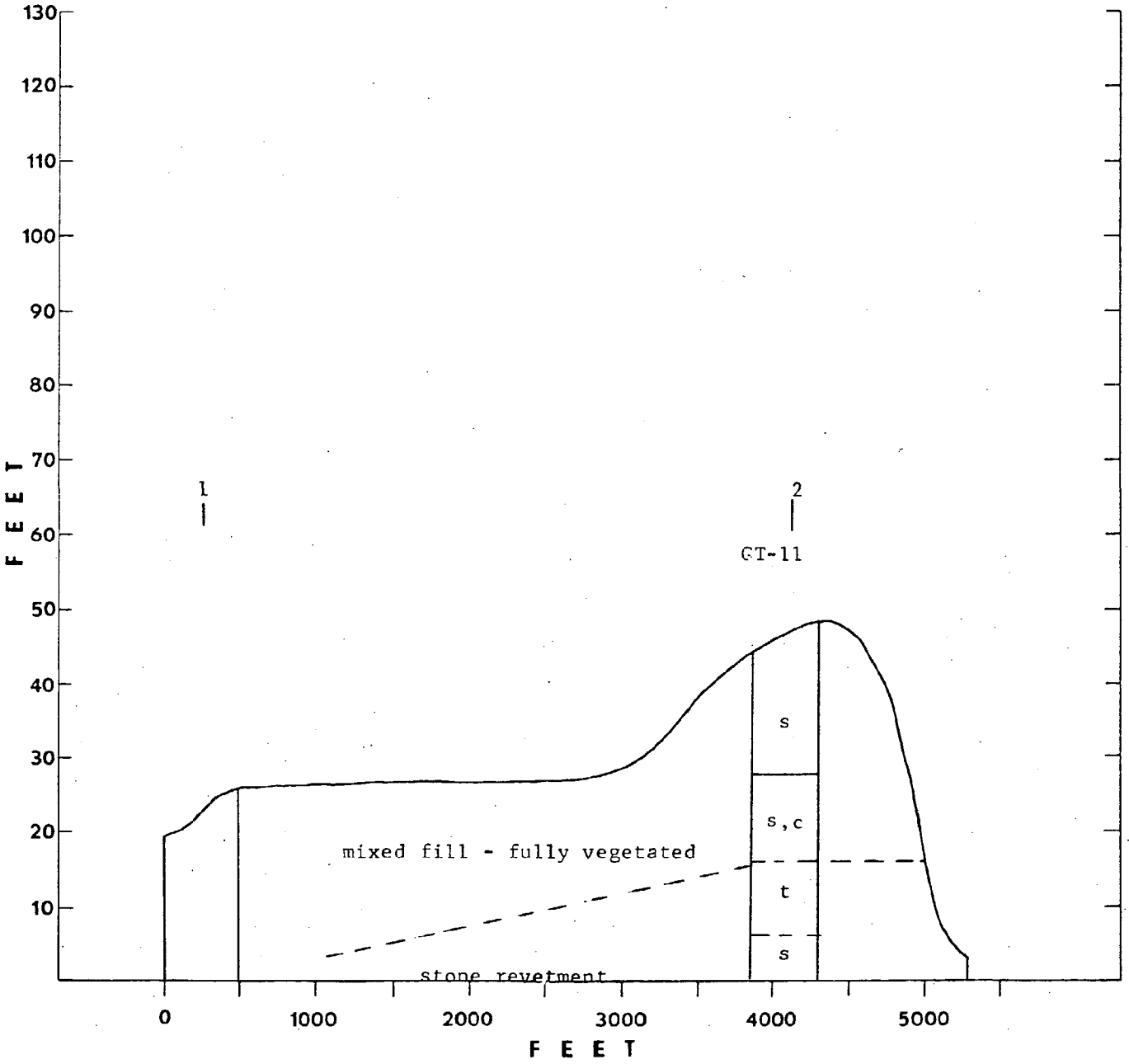


Profile 1

72 ft. to 5 ft. depth



T.15 N., R.23 E., Sec. 35



FIELD REPORT - REACH 21

Location and General Description

This reach includes the shoreline portions of Sections 14, 11, and 2 of T.15N., R.23E., and about the southern two-thirds of Section 34 of T.16N., R.23E. It has an overall priority ranking of 25, which gives it the tenth highest priority of those reaches north of Ozaukee County.

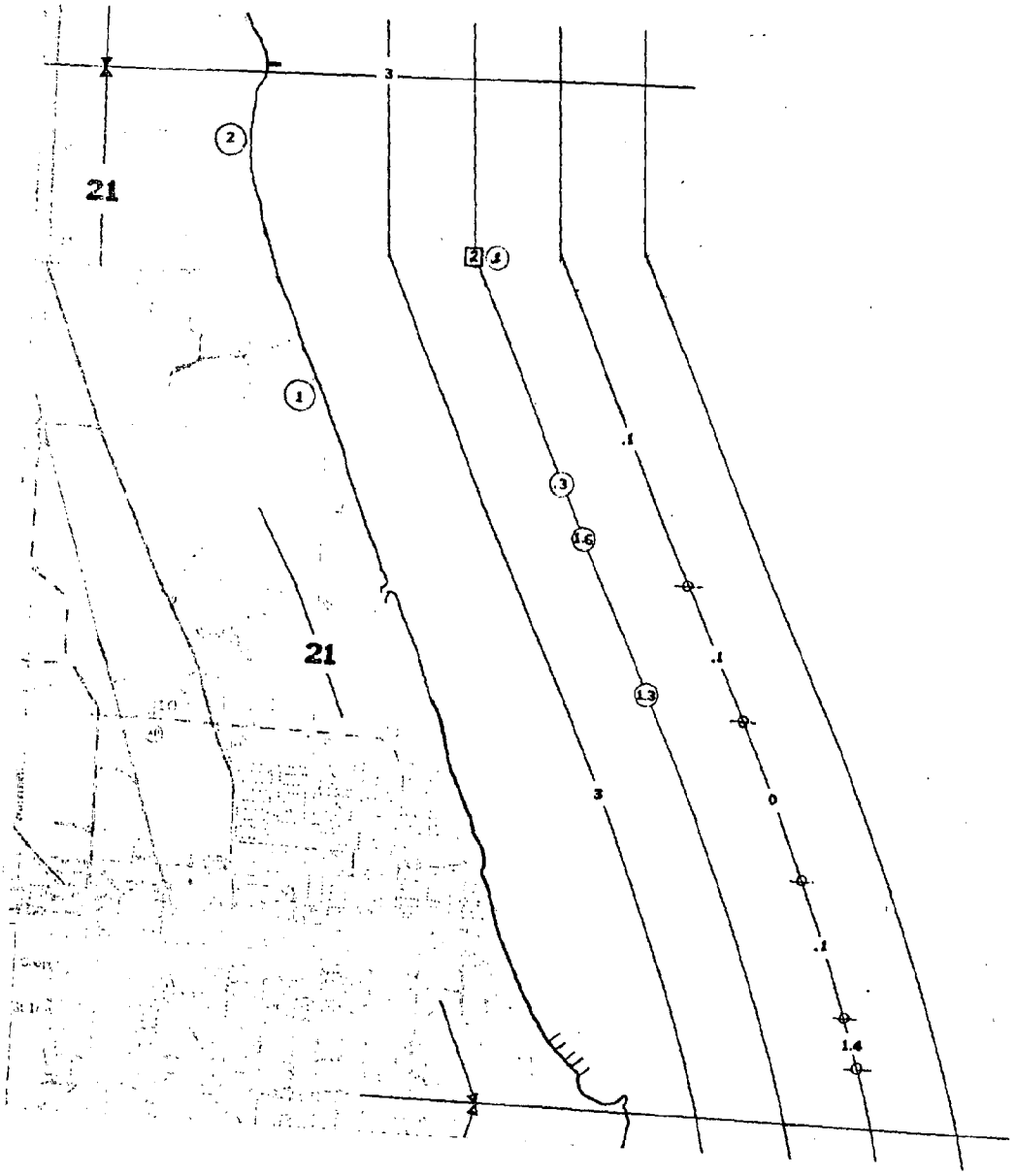
Land use within this reach is quite variable, ranging from urban residential in much of the two southernmost sections, to largely agricultural or undeveloped lands to the north where only scattered, small subdivisions indicate the close proximity of Sheboygan.

In its southern sections, the shoreline is composed primarily of granular fill placed behind heavy revetments with a moderately high bluff to the rear. Throughout the urban portions of this reach, study of the stratigraphy of the bluffs is extremely difficult due to the extensive placement of fill on the bluff face as well as a heavy vegetative cover in many areas protected by revetments.

In the less highly developed areas to the north, the shoreline generally has a moderately wide cobble beach, normally ranging between ten and thirty feet in width. In some areas in which till appears in a basal position, however, the beaches are very narrow, or, in some cases, nonexistant. The height of the bluffs throughout the reach is, for the most part, between forty and fifty feet.

Section 14

This section lies entirely within metropolitan Sheboygan. Although the shoreline throughout the section is made up of moderately high bluffs with an average height of 45 feet there are few, if any, exposures along the section where the stratigraphy can be ascertained. This is due to the fact that much of the shoreline is composed of fill that has been pushed over the bluff tops,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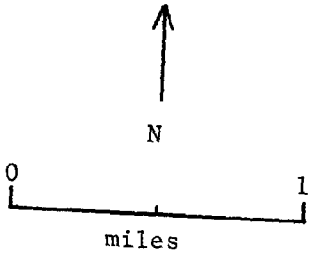
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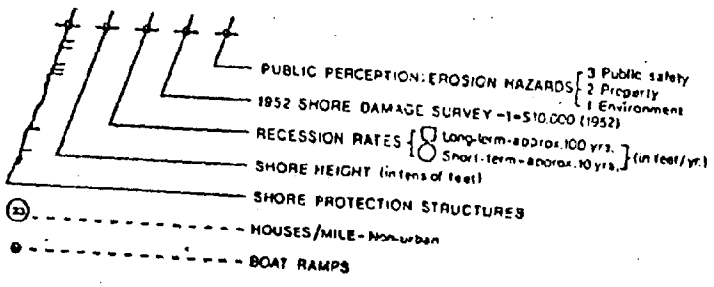
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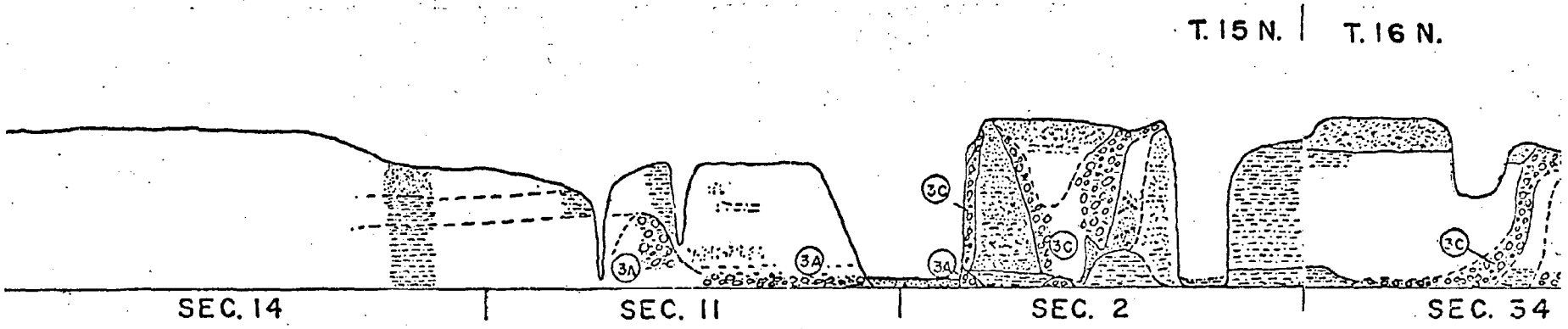
1952 SHORE DAMAGE SURVEY -1=$10,000 (1952)
RECESSION RATES { Long-term-approx.100 yrs. Short-term-approx.10 yrs. } (in feet/yr.)
SHORE HEIGHT (in tens of feet)
SHORE PROTECTION STRUCTURES
HOUSES/MILE - Non-urban
BOAT RAMPS

REACH 21



REACH 21

1000 ft.

Vertical Exaggeration = 50X

LEGEND

SAND	SILT	COVERED OR INACCESSIBLE
GRAVEL	CLAY	TILL
SAND AND GRAVEL	CLAYEY SILT, SILTY CLAY	MIXED SEDIMENTS

that many areas have been regraded and grassed, and the fact that the bluffs along most of this section are one hundred percent vegetated. In addition, the area to lakeward from the toe of the bluff through all but 2 small portions of the shoreline consists of fill material. This fill is bordered on the lake side by heavy protective structures. For the most part, this structure is a revetment made up of large dolomite blocks. Two areas of groins occur in the section. The first of these is 2 groins that lie at and immediately north of the southern section line. These are permeable groins and although there is a small area of beach associated with them, the sand appears to have been held by the impermeable portions of these structures that tie them to the shoreline and the permeable sections of the structures do not seem to be holding any appreciable amount of sand. The second area of groins is a swarm that extends from about 3.5 to 4.8. This complex consists of 5 permeable groins that are holding little or no beach and have been badly broken up by wave and ice action. The two southern most groins are tied to a sheet pile bulkhead that protects the water works, while the northern three are tied to the dolomite block revetment.

Although little or no stratigraphy could be determined through a study of the bluff, a boring (GT-12) was taken at 0.8. This boring disclosed roughly 10 feet of sand, overlying 10 to 12 feet of silt, overlying a clayey silt. This type of retrogressive sequence, that is a sequence with the grain size becoming larger as one progresses upward through the stratigraphic section, was found to be typical of the lacustrine sequences found in this protion of Sheboygan County.

The offshore area along this section is extremely complex due to the presence of large areas of dolomite bedrock above or near the water level. This is especially true from about 0.3 southward, where this shallow, exposed bedrock has been given the name "Sheboygan Reef". At Profile #2, which was

taken at boring GT-12, it was found that it was 48 feet from the shoreline to a point at which the water was 5 feet deep.

No recession rate data was available for this section. Due to the fact that almost the entire shoreline is protected by heavy structures and because much of the shoreline is further protected by the presence of bedrock at or near the lake surface, erosion would be expected to be very slight. Active erosion was observed along this section only in very localized areas, the most significant of which was chosen as the sight for boring GT-12.

Section 11

The bluffs in Section 11 average between 35 and 40 feet in height and are broken by minor valleys at about 0.3 and 0.5. From the south section line to about 0.1 the slopes are relatively gentle and fully vegetated. From 0.1 to 0.23 the slopes become steeper and the face of the bluff is covered by a fill of stone and broken concrete that had been pushed over from the top of the bluff. Between 0.23 and 0.38, the stratigraphy of the upper portions of the bluff is well exposed. At Profile #1, which is located at 0.25, about 5 feet of lacustrine silts and silty clays were exposed in a scarp above a recent slump block, and this general stratigraphy was found to carry through along this exposed portion of the bluff. The face of the bluff is once again covered with fill north to 0.43. Between this point and 0.5, there is an excellent full section of the bluff exposed. At the site of Profile #2, which is in this well exposed area, it was found that the bluff was made up of 19 feet of thin bedded silts and clayey silts, lying over at least 15 feet of a red-brown stiff silty clay till. This till was identified as being till 3A. Just north of Profile #2 the contact between the till and the overlying lacustrine sediments dips sharply to the north. Between 0.5 and about 0.66 the bluff, although steep, is fully vegetated by grasses and exposures are limited to a 2 to 5 foot high cut face at the toe of the slope. In this region there is a relatively continuous exposure of till 3A although this toe zone is,

in many areas, obscured by lacustrine sands that have slumped down from above. From 0.66 to about 0.75 the bluffs are very steep and show evidence of rapid erosion. Although lacustrine sediments are exposed in the upper portions of the bluff, much of the exposure is obscured by minor slumps and flows and no detailed study of the lacustrine sequence exposed in this area was undertaken. Near the north end of the section, at about 0.9, the ground surface drops rapidly into the valley of the Pigeon River. The northernmost 300 feet of this section are made up of a river mouth beach bar.

Only one structure was described in this section. This structure was a dolomite block revetment backed by granular fill that stretched continuously from the south section line to 0.5. A single short term recession rate measurement was available for this section. This measurement, which was made at about the midpoint of the section, showed an average erosion rate of 3 feet/year.

From the southern section line to about 0.7 land usage is primarily urban residential. From 0.7 north to the valley of the Pigeon River the land along the shoreline is largely undeveloped.

Sections 2 and 3

The geology and stratigraphy as exposed in this stretch of the shoreline is exceedingly complex. The authors will therefore attempt to generalize in this description and the reader is urged to refer to the more detailed information shown graphically in the longitudinal and transverse profiles.

The shoreline in this area can be subdivided into four basic units. The first of these, which extends from the southern section line to 0.15, is made up of a bar extending across the mouth of the Pigeon River. The second area, which extends from 0.15 to 0.64, is made up of steep bluffs ranging up to 50 feet in height and having many areas in which rapid erosion is taking place. Along most of this segment the major mechanism of erosion is the undercutting of the bluff by wave action against the toe and subsequent soil falls. In limited areas, slumping and soli-

fluction also play important roles. Although the geology of this unit of the shoreline is very complex it is possible to develop a generalized stratigraphic section. The youngest unit exposed is a sequence of sandy lacustrines lying unconformably on the surface of a highly oxidized and pebbley red till which was identified as till 3C. This till is in turn underlain by a thick sequence of sands and silts. In the northern portions of the area a bed of sand and gravel is found between the till and the underlying silt. Beneath the silt is a thick massive gray silt. This silt is exposed along the toe of the slope over much of the reach and in some areas has been eroded back to form a series of cave-like features. Underlying the gray silt and exposed at several points along the beach is a second red-brown till, which was identified as till 3A. Major seepage zones have developed on the contact between the massive gray silt and the overlying sandy and silty sediments, and on the upper surface of till 3C.

The third shoreline area, which extends to 0.84, is made up of alluvium deposited in the valley of an unnamed stream that flows into the lake at this location.

The fourth area, which extends from 0.84 to the northern section line, is another area of rapid erosion. Bluff height here is between 40 and 45 feet and the stratigraphy is well exposed. The bluffs are made up of about 3 feet of sand overlying 35 feet of thick bedded silts and clays, which in turn overlie a 5 foot bed of clayey silt. No tills are exposed in this unit. A major seepage zone is found at the base of the upper sand bed.

Two short term recession rate measurements are available in this section, both lying in the southern half of the section. One, which ties at about 0.3, gives a value of 1.6 feet per year while the other, which lies at about 0.45, gives a value of 0.3 foot per year.

The area is largely undeveloped with a housing density of 1 house per mile. Although some of the area along the top of the bluff is in agricultural use, much

of it appears to be slated for eventual housing developments.

One structure, a revetment, was mapped at about 0.8 just to the north of the stream valley. A single water depth measurement was made near this structure and showed the water depth 50 feet from shore to be between 1 and 2 feet. A single well developed sand bar is visible on the vertical air photographs and also from the top of the bluff.

Section 34, T.16N.

The boundary between Reaches 21 and 22 lies about 0.3 mile south of the northern boundary of Section 34. For convenience, the description of the section in its entirety will be included in the text for Reach 21.

At the southern boundary of the section, the bluffs are 43 feet high and exhibit active erosion with slumping and secondary flows the principle mechanisms of slope failure. By 0.1 the bluff height has increased to 50 feet. At the site of Profile #1, which was taken at .06, the exposed stratigraphy at the scarp zone at the head of the slumped material showed 10 feet of sand overlying about 15 feet of exposed silt and clay. Although the lower two-thirds of the section were covered by slumped silt and clay at the site of Profile #1, exposures in the area immediately to the south disclosed that the base of the bluff remained constant until about 1.1 at which point a red-brown till appeared at the base of the bluff. The till was identified as till 3C. Coincident with the appearance of this basal till, the nature of the bluff changed dramatically. The small high angle slumps that occurred in the area to the south were replaced by large slump blocks often involving the entire face of the bluff, with some sequential slumping and secondary flows. Exposures in this portion of the shoreline were confined to the upper scarps along the bluff tops where it could be seen that the thick sand unit and underlying silt and clay could be traced northward to about 0.29. At 0.29, the height of the bluffs

showed a rapid decrease, dropping to about 25 feet. At this point, the nature of the face of the bluff also showed a distinct change and the large full-faced slumps found immediately to the south gave way to a series of smaller slumps and flows of the fine grained lacustrines which completely obscured the bluff face. At scattered points along the toe of the slope, however, recent wave erosion had exposed till 3C in a basal position.

At about 0.55 the bluff rose rapidly to a height of about 40 feet and large scale slumping of the entire face of the bluff once more became the dominant mechanism of slope failure. At about this point, the basal till was replaced by a lacustrine silt in exposures along the toe of the slope. Scattered exposures on the bluff face showed that till 3C rose from a basal position at this point and by about 0.7, had risen to the extent that it was now exposed at the top of the bluff. At about this same point till 3A appeared in a basal position in the bluffs. At the large unnamed point that marks the division point between Reaches 21 and 22, the entire bluff face appeared to be made up of till. At this point the bluff is about 40 feet high and is made up of about 5 feet of till 3C overlying 35 feet of till 3A. In this region till 3A has a very high boulder content and the area in front of the projecting point of land consists of a 35 foot wide accumulation of slumped or residual erratic boulders. The protection afforded by this boulder pile may well account in large part for the presence of the projecting point of land. North of the reach boundary the contact between the two tills plunges to the north where it disappears under slumped lacustrine sediments which were deposited on top of till 3C. Till 3C appears to pinch out at about this point and at the site of Profile #2, which was taken at about 0.78, the bluff was found to be composed of about 20 feet of lacustrine sediments overlying till 3A. The contact between the till and the overlying lacustrines continues to drop across the minor valley that occurs at about .85 and at

Profile #3, taken at 0.98, the contact was only about 10 feet above beach level. By the time Profile #3 was reached, till 3C had reappeared in the upper part of the section and the general stratigraphy at the profile was about 10 feet of finely bedded silt, sand and clay overlying a 2 foot thick bed of till 3C, a covered zone of about 20 feet and finally, a thin exposure of lacustrine sand overlying till 3A. In those relatively high bluff sections occurring north of the boundary between Reaches 21 and 22, rapid erosion of the slopes was evident and the major mechanisms of slope failure appear to be undercutting and subsequent soil fall with some solifluction of the lacustrine materials.

In the extreme southern 0.1 of a mile beaches are largely of sand and between 40 and 60 feet in width. From about 0.1 northward to the northern section line the beaches are primarily cobble beaches and average 35 feet in width.

Recession rate data for a point near the southern section line indicates a long term average erosion rate of 2 feet/year and a short term average of 0.1 foot/year.

One structure was present in this section. This was a small sand bag revetment that occurred at about 0.6.

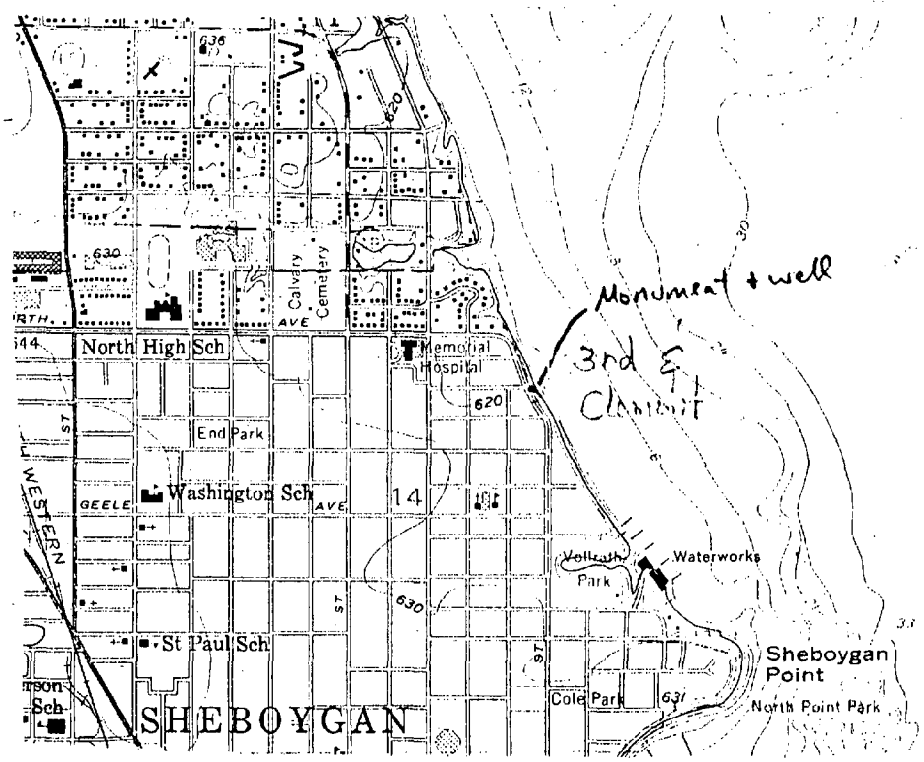
Housing density was given as 2 houses per mile. Most of the development in the shoreline area was concentrated in the northern third of the reach in proximity to the unnamed point that separates Reaches 21 and 22 and most of the upland area along the bluffs within this section is in agricultural use. Water depths could not be accurately determined because of the extremely wavy conditions during the occasions in which the authors were in this section. Depths of between 2 and 3 feet were estimated.

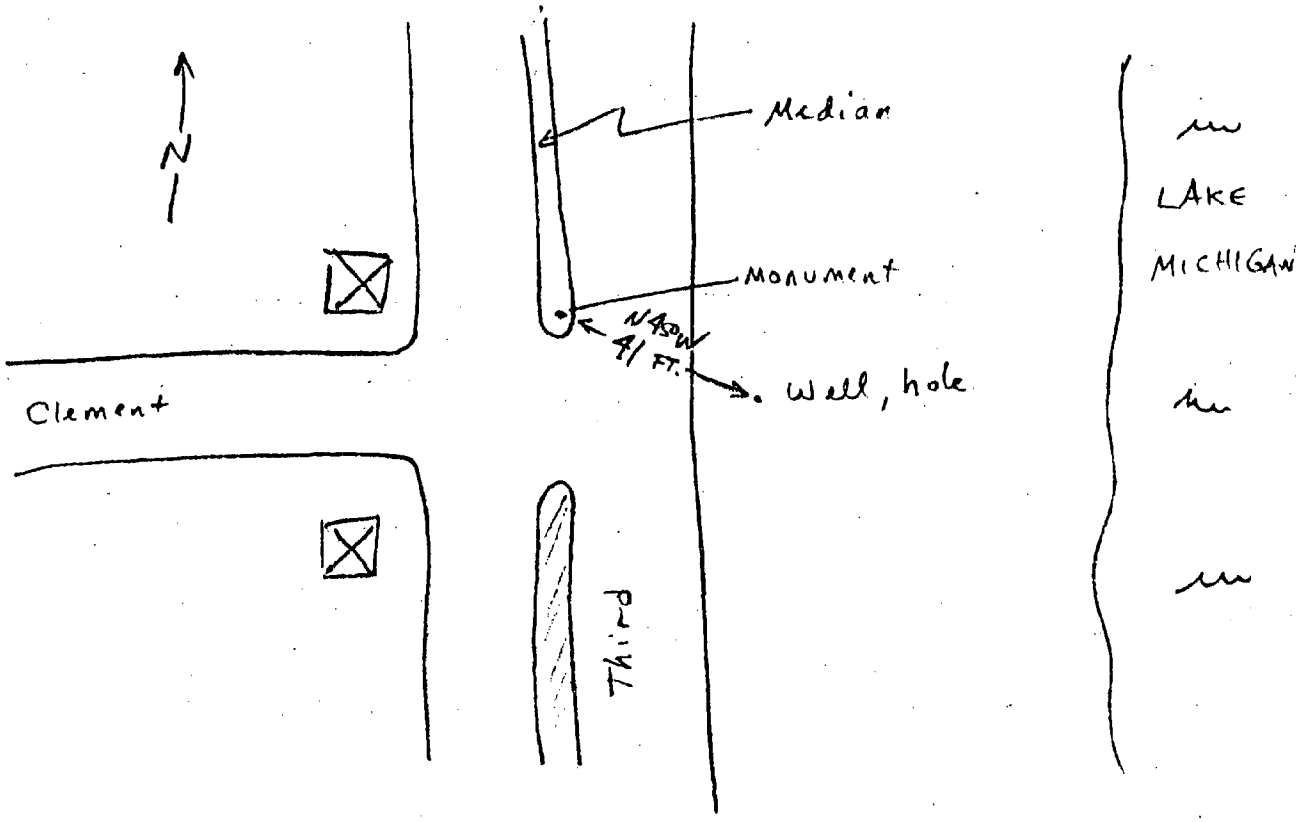
LOCATION AND MONUMENTATION SKETCHES

Boring No. GT-12, Sheboygan Co., Sheboygan North Quad, NE¼ / Sec. 14 / T. 15 N. / R. 23 E.

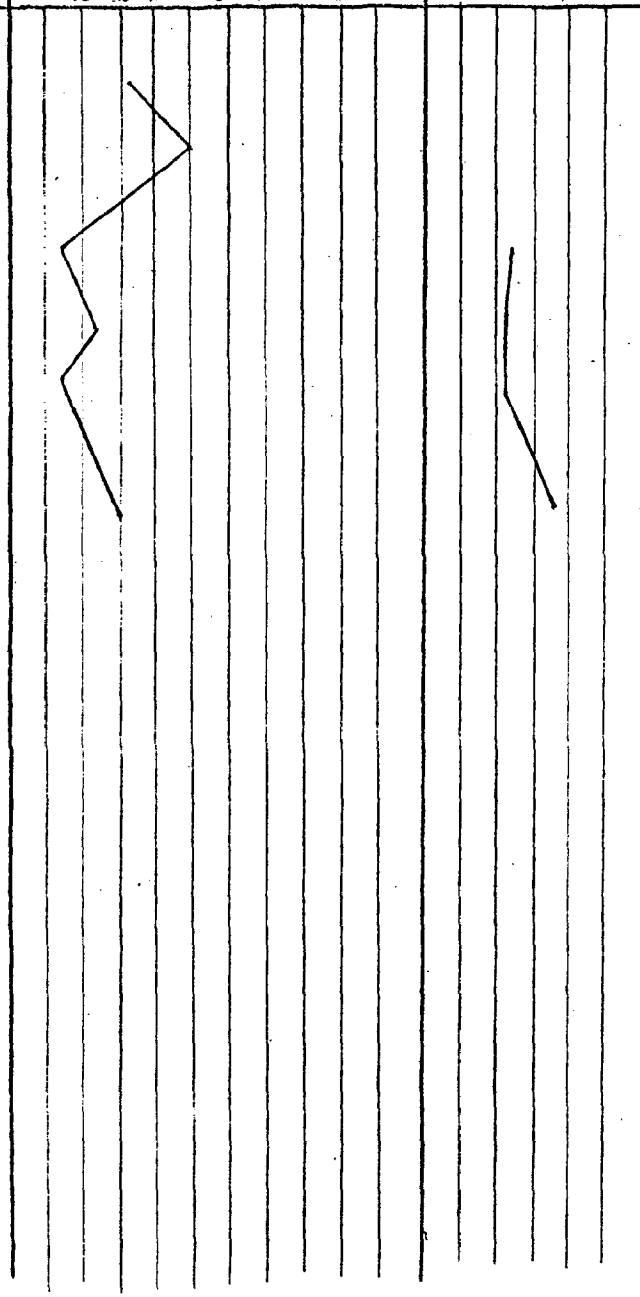
Date

Drawn by





Borehole: GT-12 Location: No. Sheboygan, Sheboygan County, Sec. 14, T15N

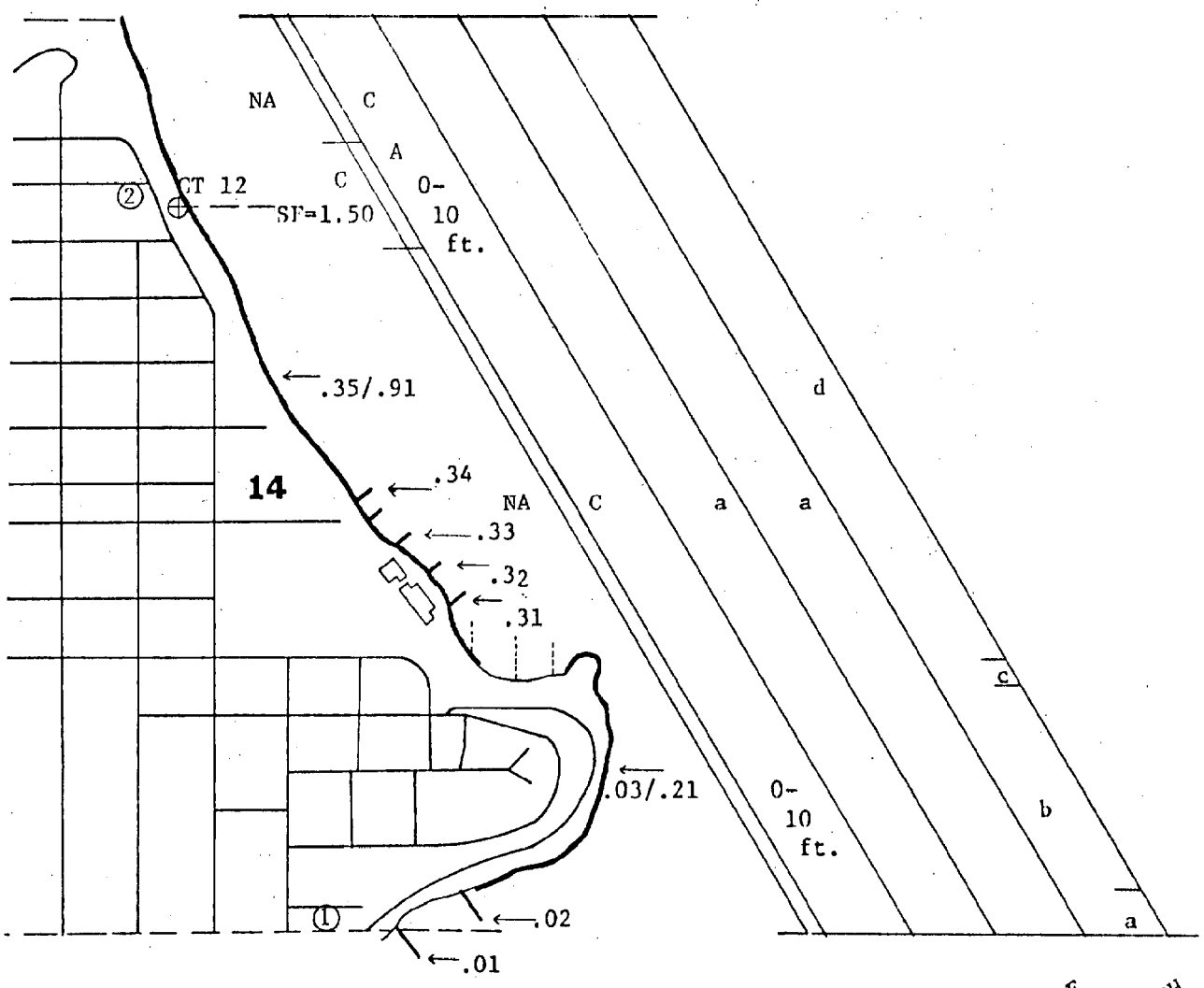


Depth (feet)	w_n %	γ_d (psf)	w_L %	I_P %	% Clay	% Clay & Silt	$\phi°$	c (psf)	c_{vane} (psf)	USCS class.
5	14.8	124					39.4	0		SP
10	14.7	124	(non-plastic)		4.5	83.8				ML
15										
20	19.3	115	24.2	8.2			28.7	511		
25										
30	25.1	100	35.6	16.3	42.0	99.8	28.7	511		CL
35			33.4	16.0						
40	22.9	104	33.4	13.9			28.7	511		
45	17.3	116	30.6	14.3			30.0	696	696	
50										
55			29.0	12.6						CL-ML

yellow sand — 9'
grey silty sand — 17'
brown silty clay — 47'
red clay (till)

64

T.15N.,R.23E.,Sec.14



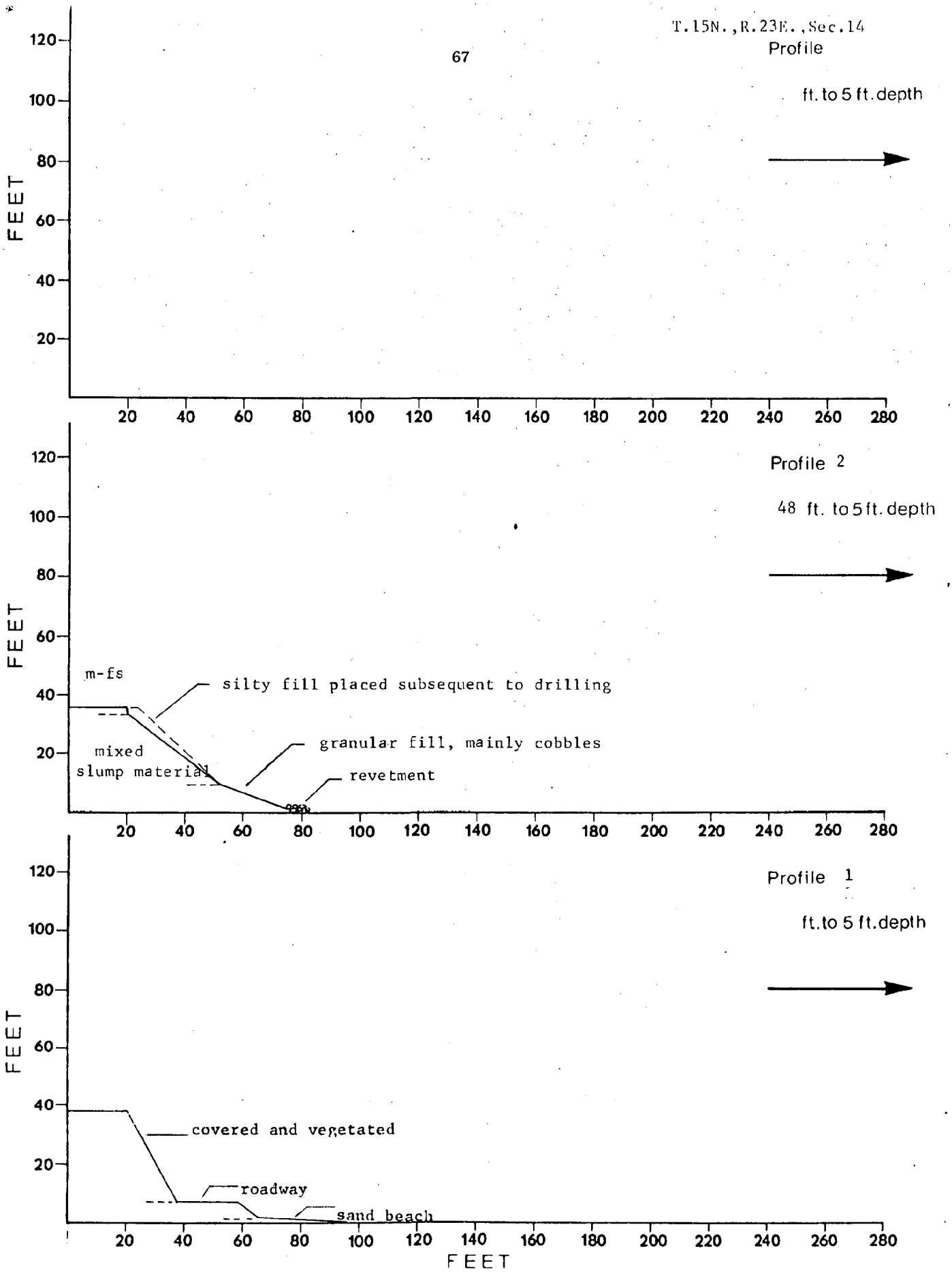
SAFETY FACTOR

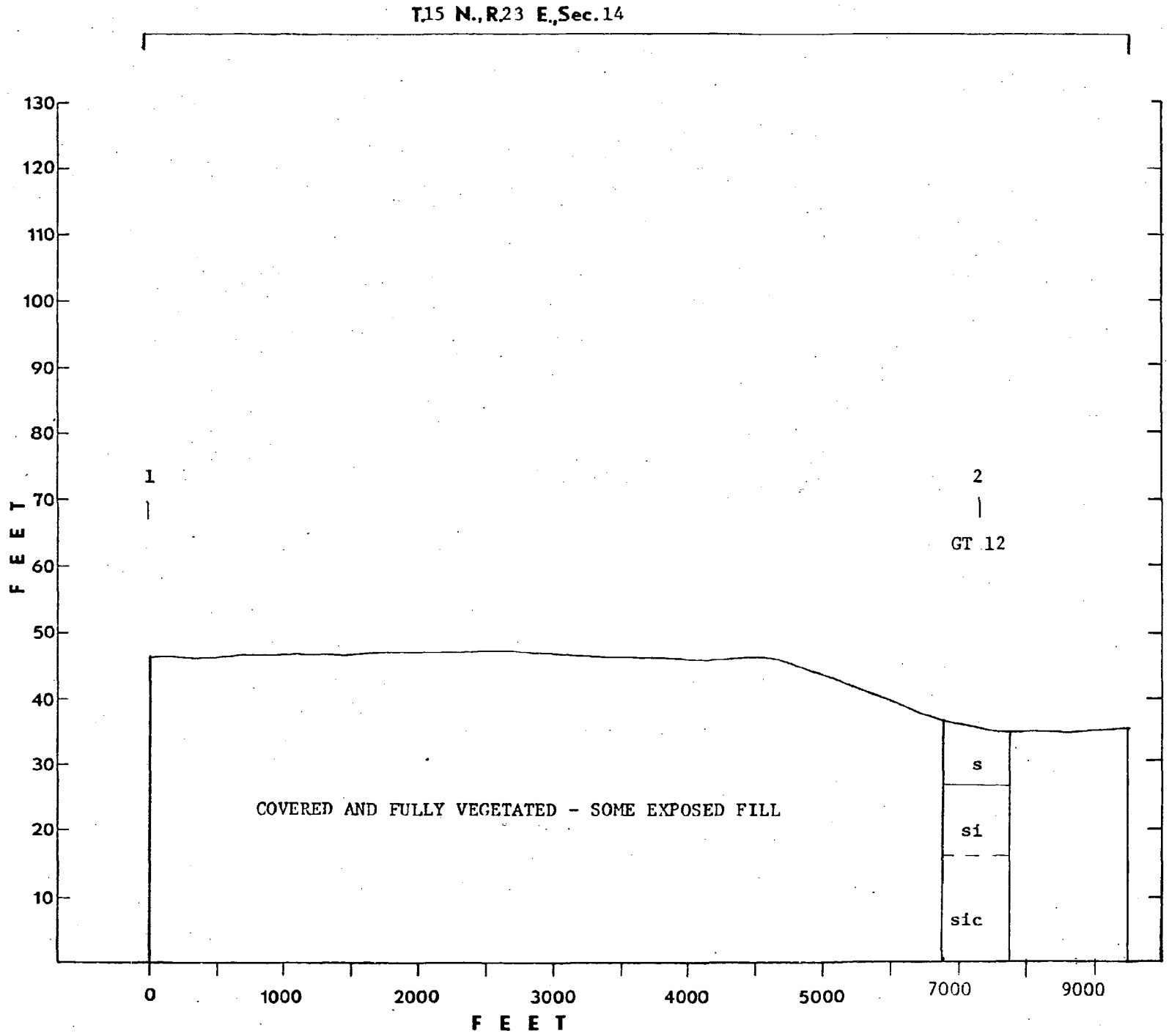
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

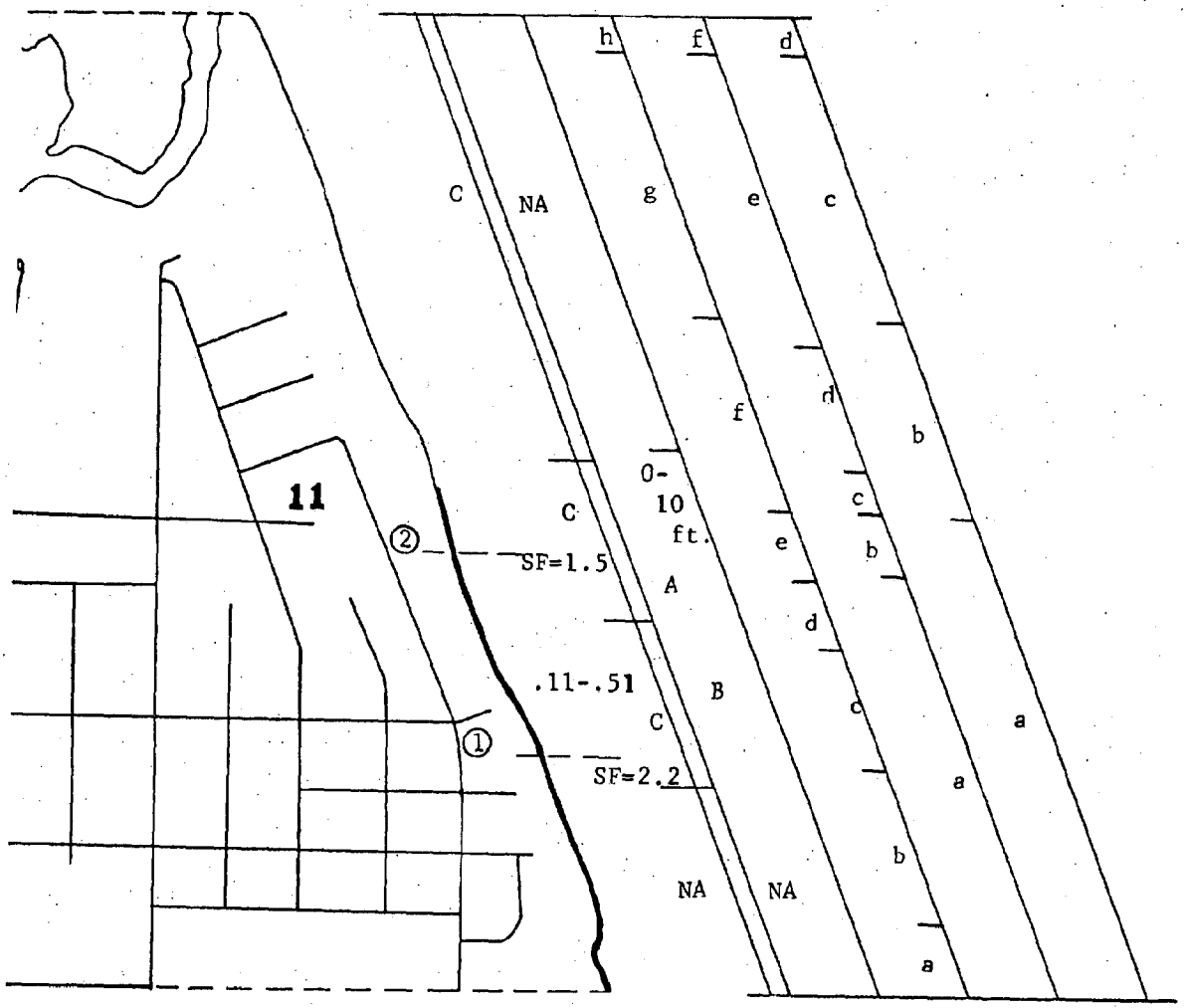
CONFIDENCE LEVEL

A-boreholes
(high confidence)
B-near boreholes
stratigraphy visible
C-no stratigraphy
visible (low
confidence)

1. BLUFF	a-bluff covered and fully vegetated, some exposed fill			
2. TOE	a-largely fill behind revetment			
3. BEACH	a-30-50 ft. sand beach	b-no beach	c-0-30 ft. sand beach	d-no beach


T.15N.,R.23E.,Sec.14
Profile
ft. to 5 ft. depth
FEET
120
100
80
60
40
20
20 40 60 80 100 120 140 160 180 200 220 240 260 280
Profile 2
48 ft. to 5 ft. depth
m-fs
silty fill placed subsequent to drilling
granular fill, mainly cobbles
mixed
slump material
revetment
Profile 1
ft. to 5 ft. depth
covered and vegetated
roadway
sand beach
FEET


T.15 N., R.23 E., Sec. 14
130
120
110
100
90
80
70
60
50
40
30
20
10
FEET
1
2
GT 12
COVERED AND FULLY VEGETATED - SOME EXPOSED FILL
s
si
sic
0
1000
2000
3000
4000
5000
7000
9000
FEET



T.15N.,R23E.

SAFETY FACTOR
CONFIDENCE LEVEL
STABILITY LINE
BLUFF
TOE
REACH

SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

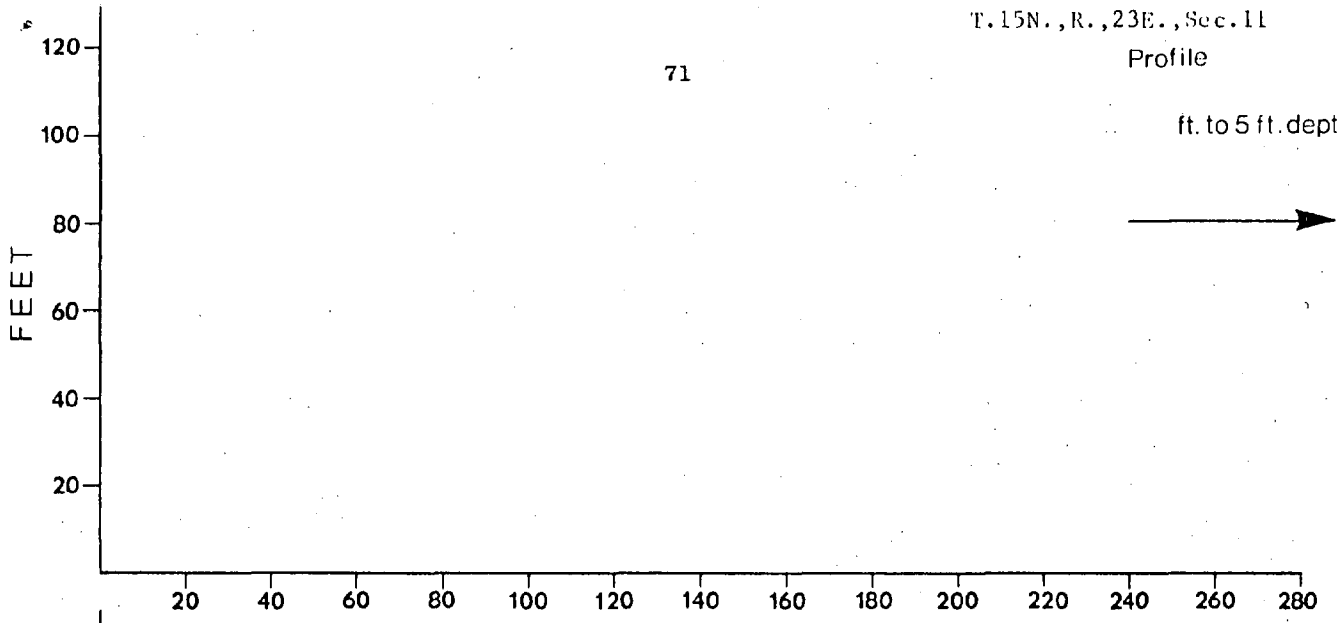
CONFIDENCE LEVEL
A-boreholes
(high confidence)
B-near boreholes
stratigraphy visible
C-no stratigraphy
visible (low
confidence)

1. BLUFF	a-gentle grassed slope	b-steep slope with veneer of fill, largely concrete rubble	c-steep, actively slumping slope in lacustrine silts and clays	d-steep slope, face obscured by concrete rubble fill
	e-steep and actively eroding slope, erosion largely through sapping and subsequent soil fall	f-steep, but largely vegetated slope, active erosion at toe, slopes 75-90% vegetated, largely in grasses	g-very steep and actively eroding slope; slumping, flows, soil falls, and solifluction all active agents	h-no bluff
2. TOE	a-coarse granular fill behind revetment	b-red-brown till (erosion behind revetment)	c-red-brown till	d-sand (may be slumped)
	e-red-brown till	f-beach sand		
3. BEACH	a-no beach	b-10-40 ft. cobble beach	c-no beach	d-stream mouth beach bar

T.15N.,R.,23E.,Sec.11

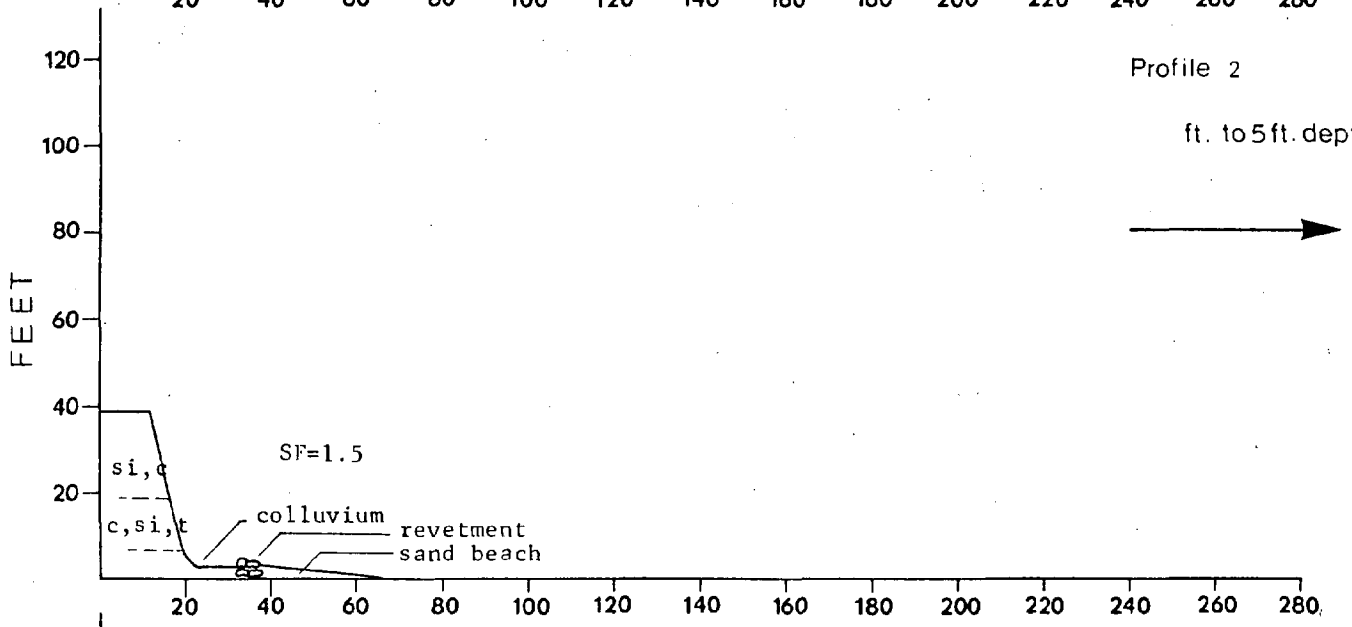
Profile

ft. to 5 ft. depth



Profile 2

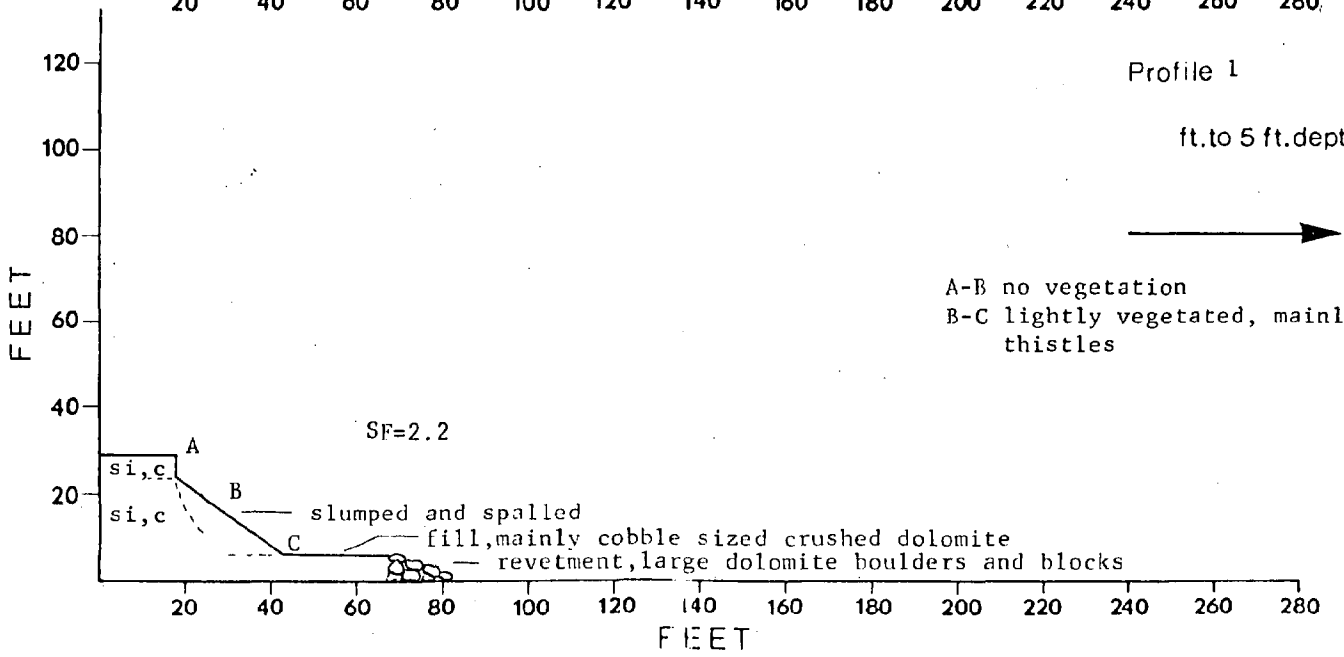
ft. to 5 ft. depth

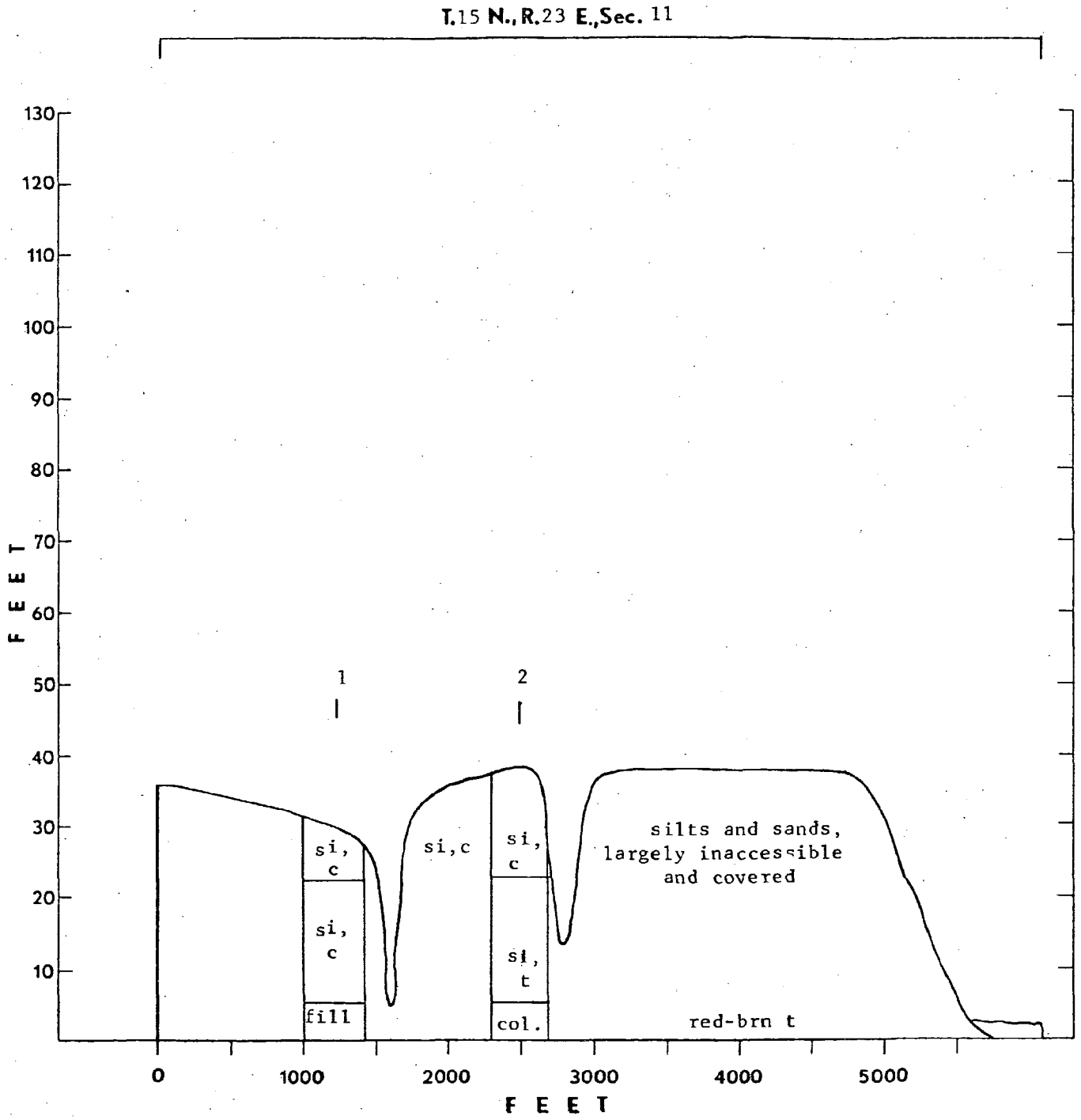


Profile 1

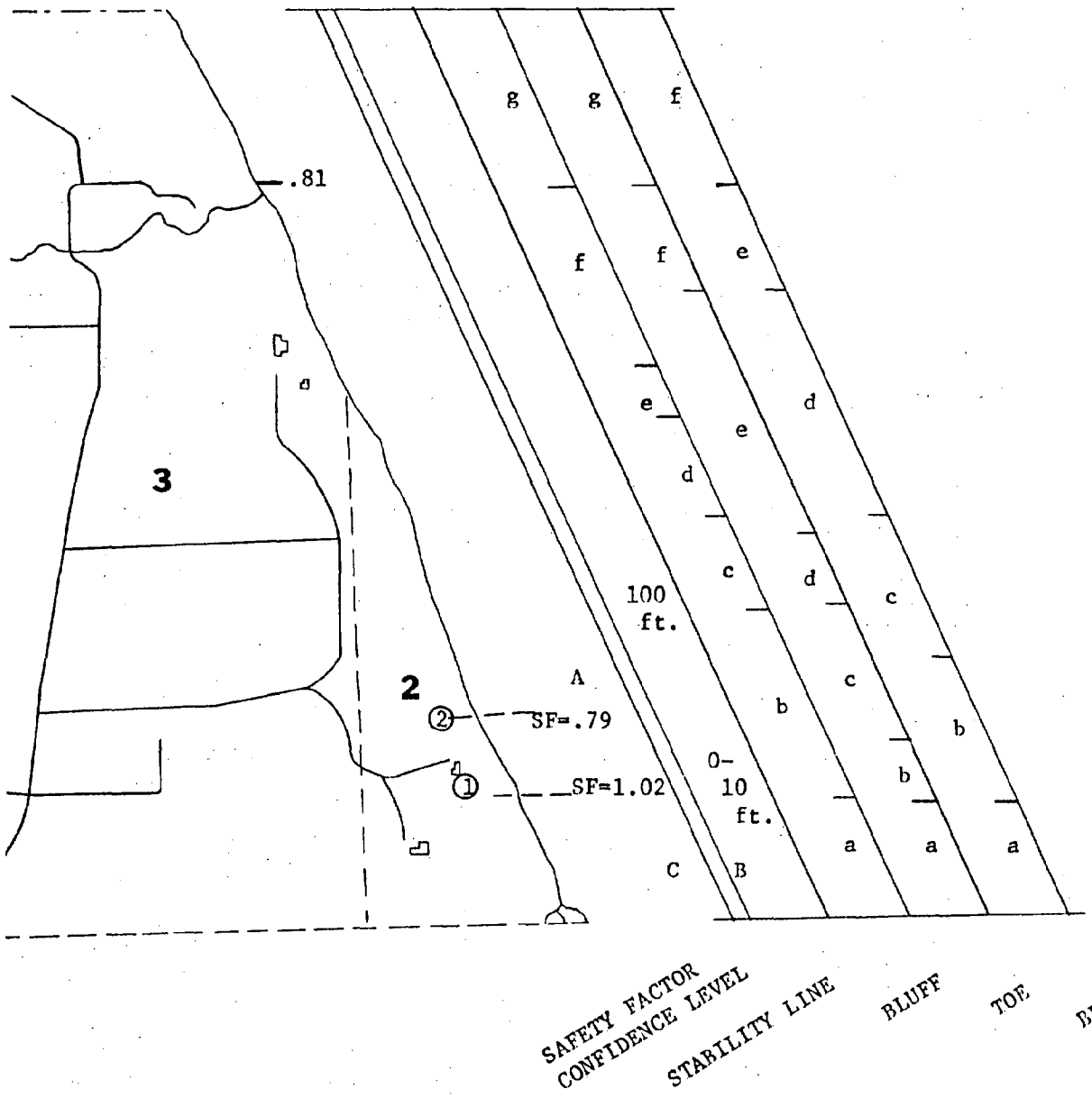
ft. to 5 ft. depth

A-B no vegetation
B-C lightly vegetated, mainly thistles




T.15 N., R.23 E., Sec. 11
130
120
110
100
90
80
70
60
50
40
30
20
10
FEET
1
2
si, c
si, c
fill
si, c
si, t
col.
si, c
silts and sands, largely inaccessible and covered
red-brn t
0
1000
2000
3000
4000
5000
FEET

T.15N.,R.23E.,Sec.2/3



SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

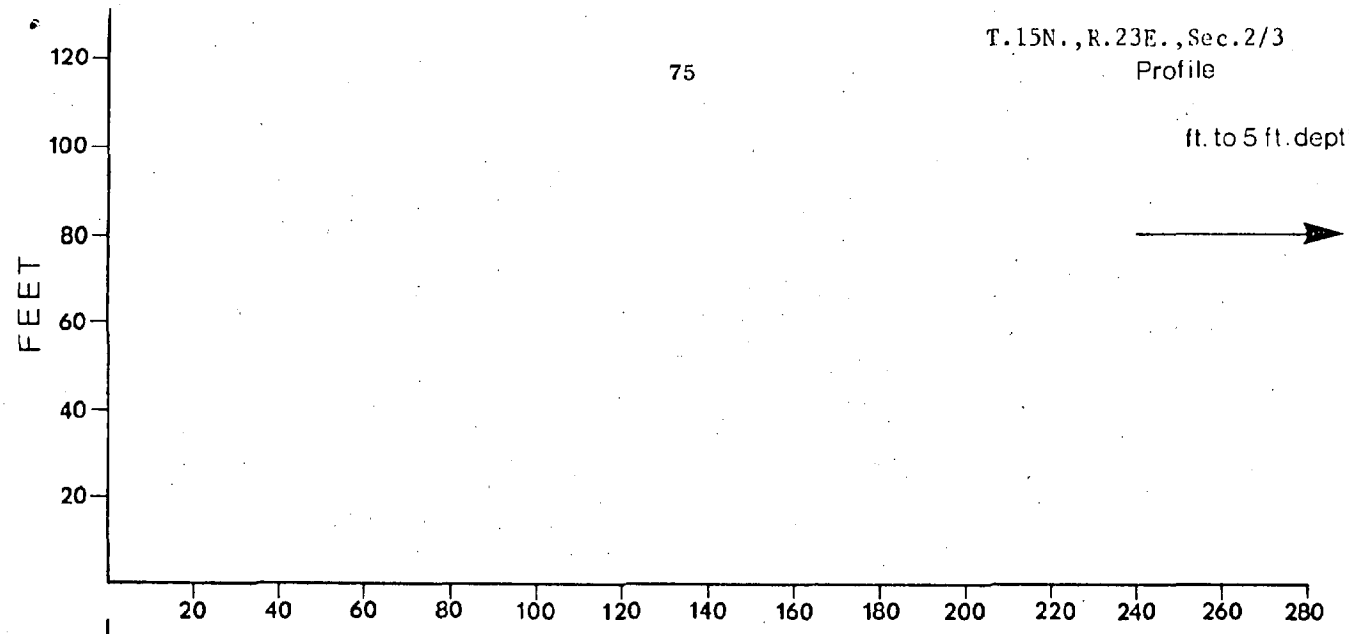
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	a-no bluff	b-steep, actively eroding slope, many cave-like features in basal silt unit; solifluction, sapping and soil falls major mechanisms	c-50-85% vegetated, slumping in lower units largely obscures unvegetated portions of slope	d-steep, actively eroding slope, soil fall and solifluction predominate
	e-covered and fully vegetated	f-little or no bluff	g-steep actively eroding slope, soil falls and minor slumping	
2. TOE	a-sand bar	b-till	c-silt	d-till
	e-silt	f-alluvium	g-silty clay	
3. BEACH	a-sand bar	b-0-50 ft. sand and cobble	c-10-20 ft. cobble	d-20-30 ft. sand and cobble
	e-30-50 ft. sand and cobble	f-30-50 ft. sand beach		

T.15N.,R.23E.,Sec.2/3

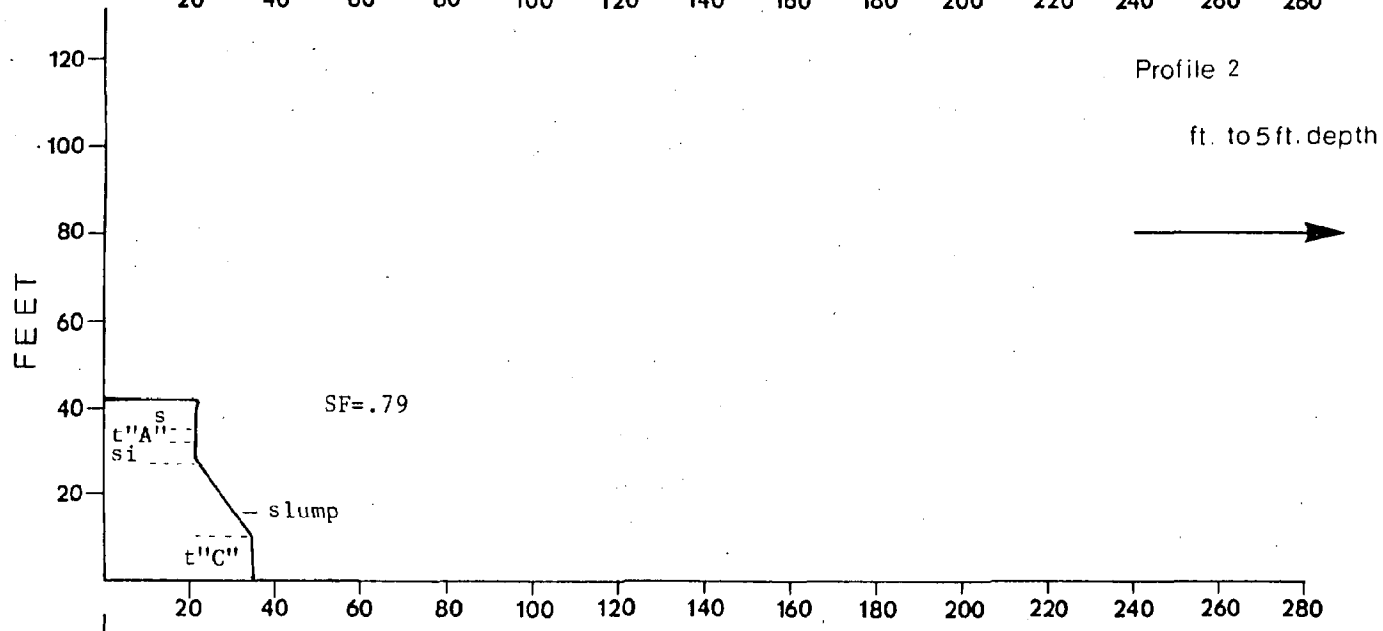
Profile

ft. to 5 ft. depth



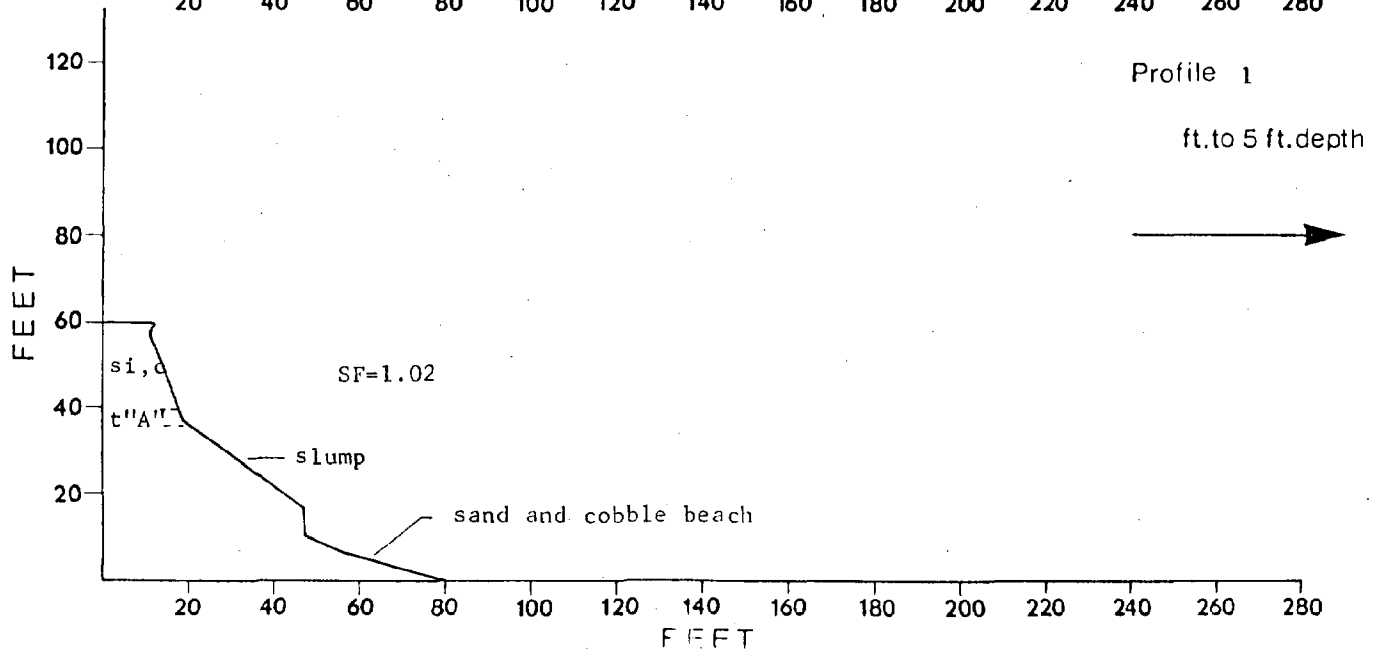
Profile 2

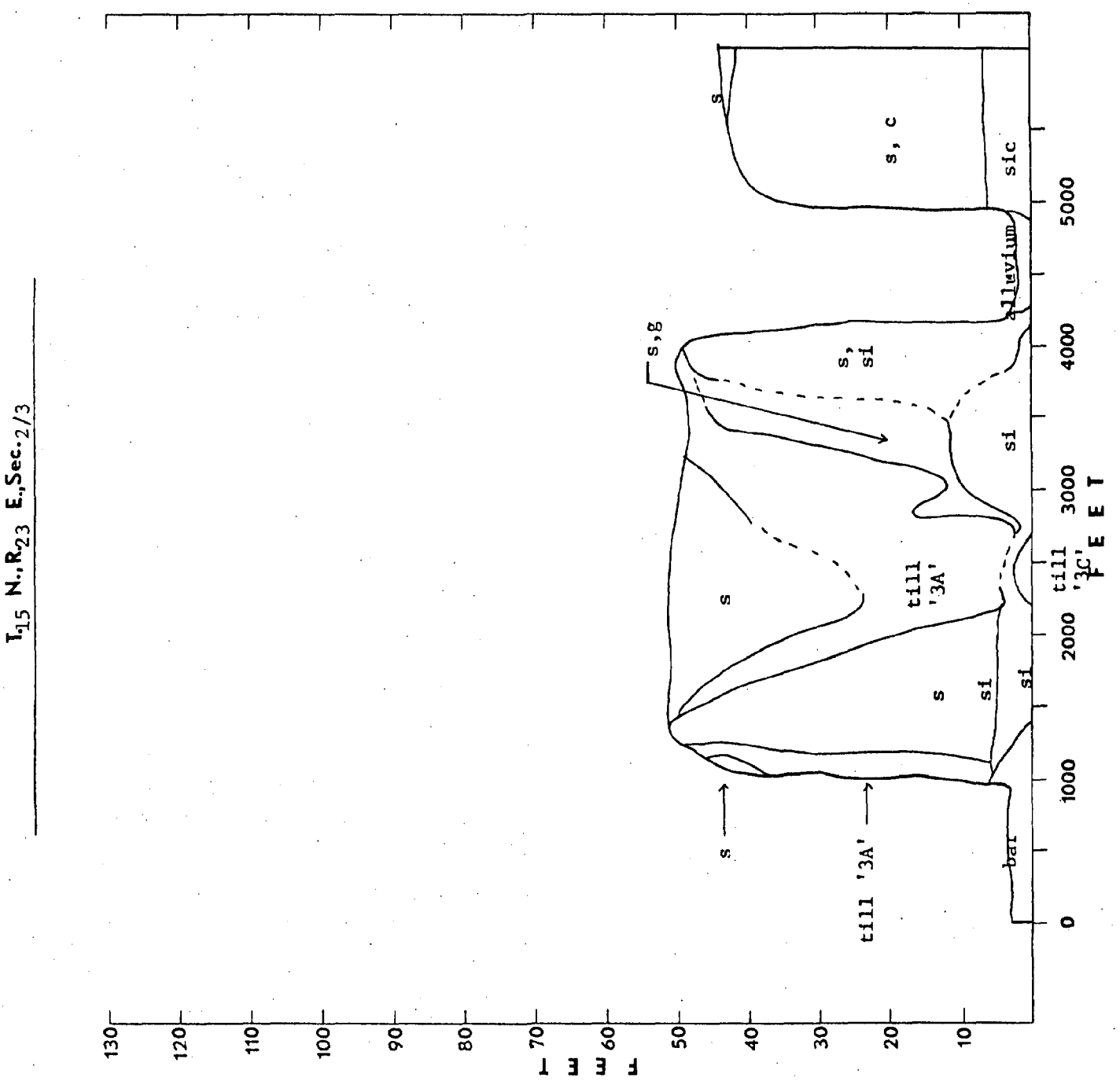
ft. to 5 ft. depth

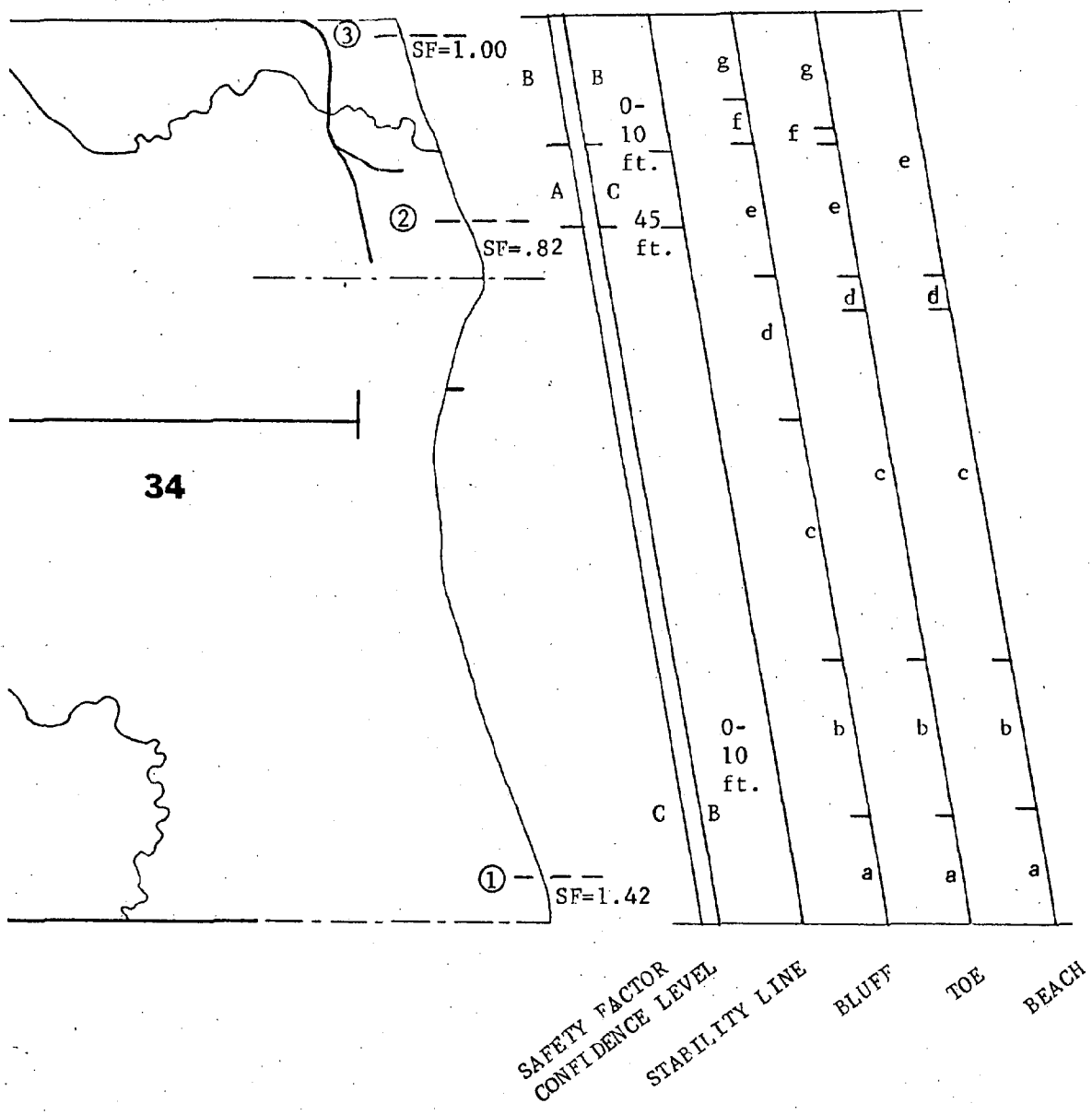


Profile 1

ft. to 5 ft. depth




T15 N.,R23 E.,Sec.2/3
FEET
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
FEET
s
s, c
sic
alluvium
s,g
s, si
si
s
till '3A'
till '3C'
s
si
si
s
till '3A'
bar



SAFETY FACTOR

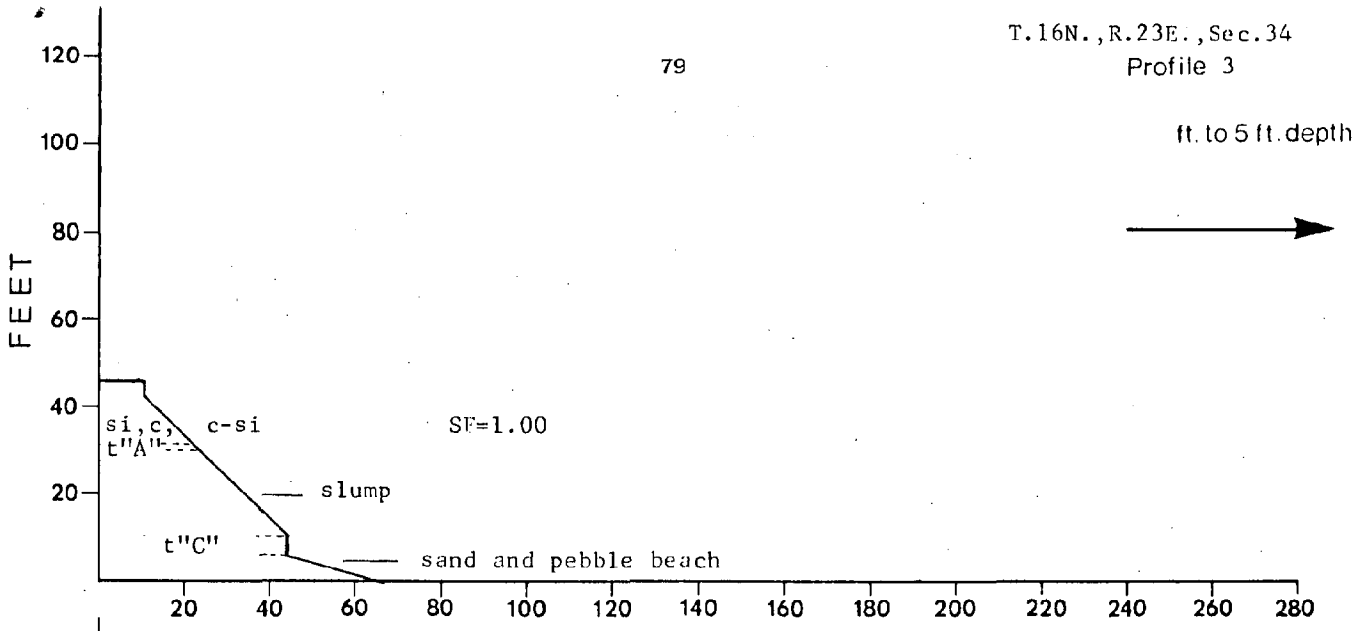
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

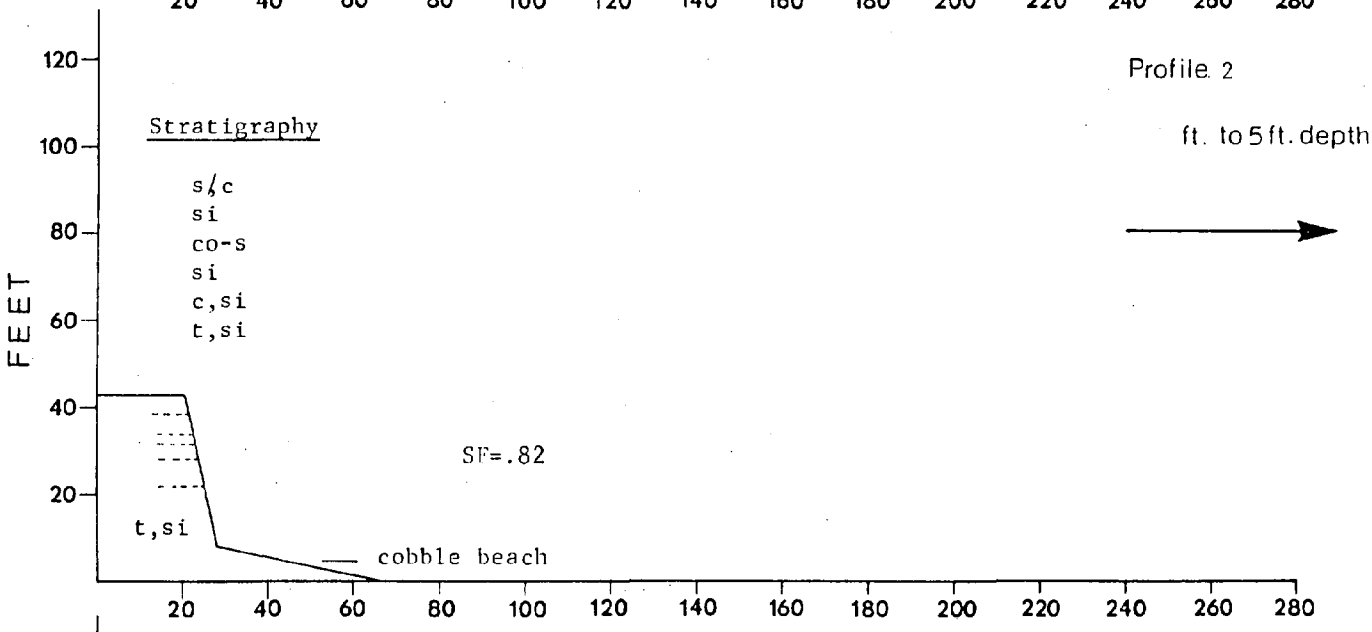
A-boreholes
(high confidence)
B-near boreholes
stratigraphy visible
C-no stratigraphy
visible (low
confidence)

1. BLUFF	a-steep slopes; slumping and flows major processes; slope 25% vegetated	b-large scale slumping, some secondary flows	c-wide spread slumping with many secondary or associated flows; more than 90% vegetated	d-slumping of full face, many secondary slumps and flows; 50-100% vegetated
	e-steep rapidly eroding slopes, sapping and soil fall major mechanisms	f-little or no bluff	g-steep rapidly eroding slopes, soil fall major mechanisms	
2. TOE	a-slumped silt and clay	b-red-brown till	c-slumped silt	d-till behind residual boulders
	e-red-brown till	f-alluvium	g-red-brown till	
3. BEACH	a-40-60 ft. sand and cobbles	b-30-40 ft. cobbles	c-20-30 ft. cobbles	d-0-35 ft. boulders and cobbles
	e-35 ft. cobbles			

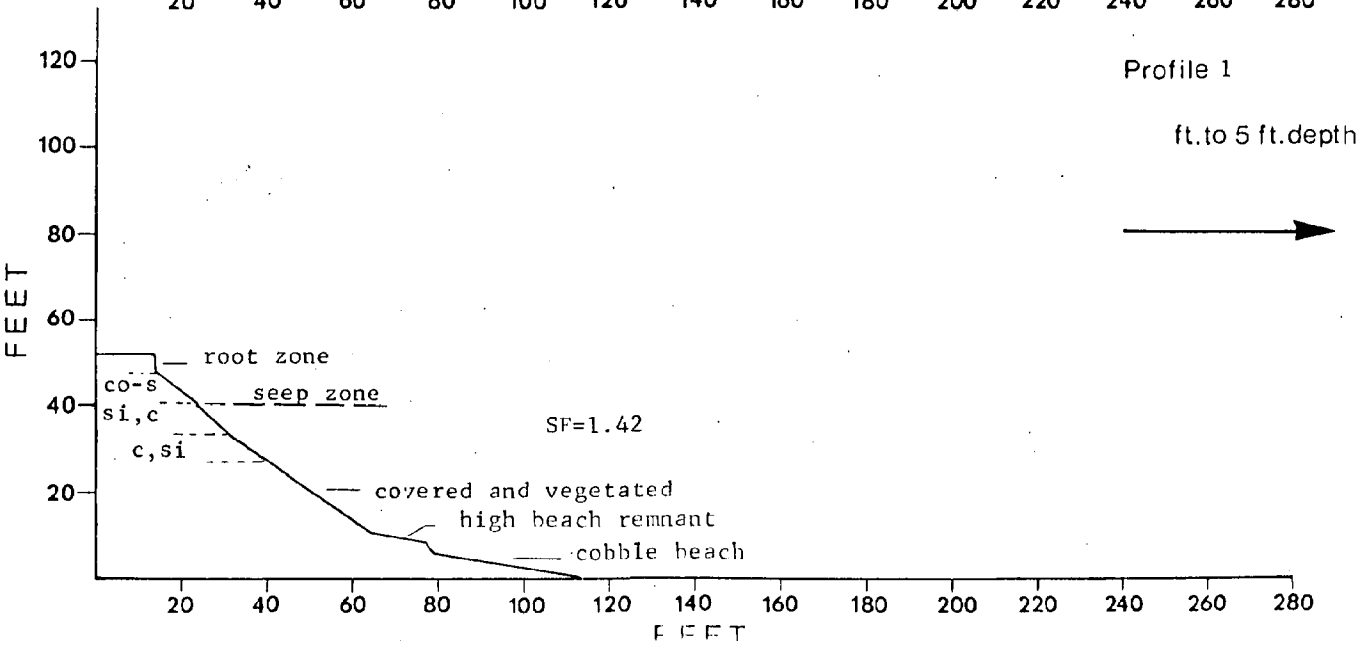
T.16N.,R.23E.,Sec.34
Profile 3

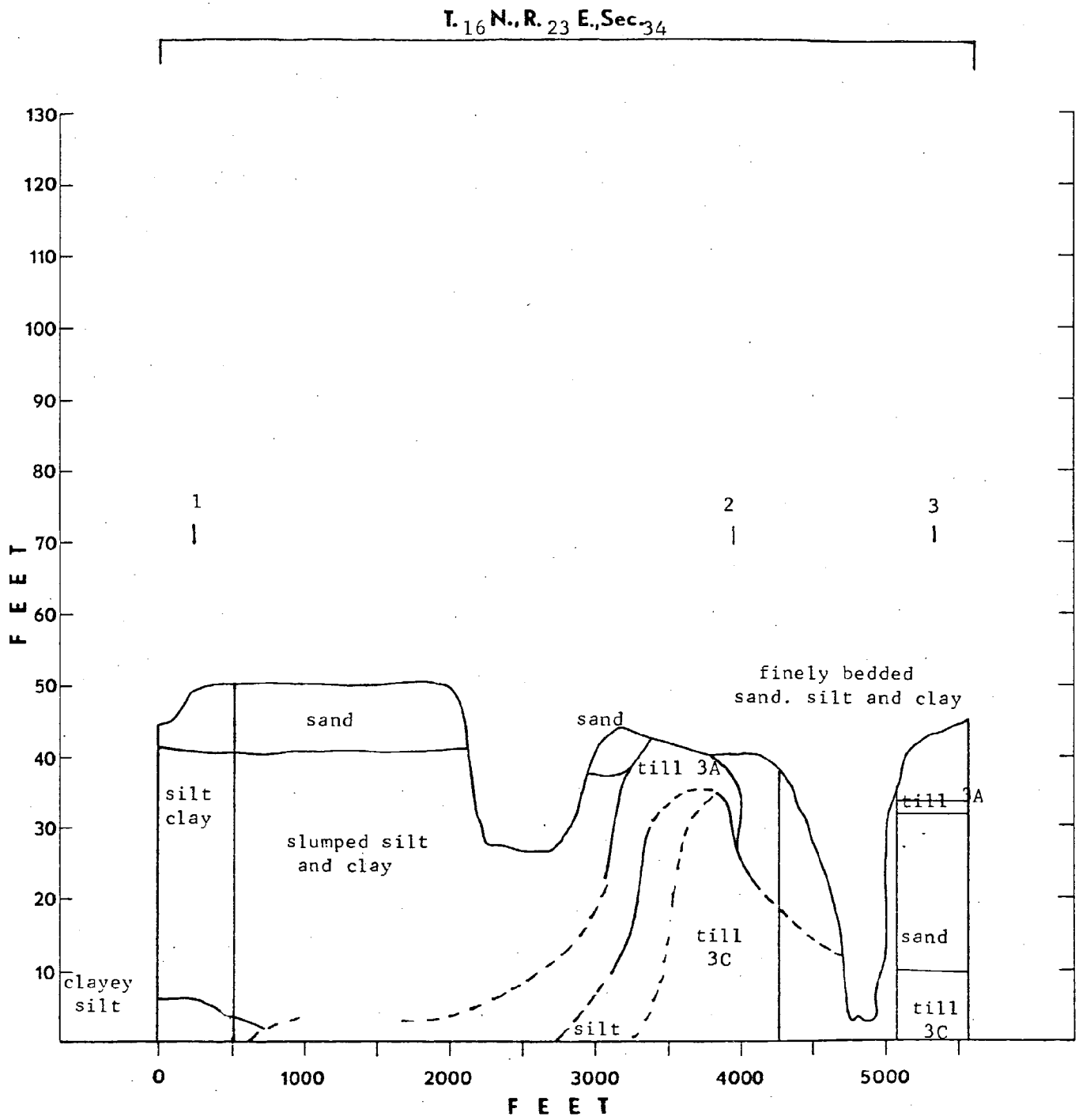


Profile 2



Profile 1




T. 16 N., R. 23 E., Sec. 34
130
120
110
100
90
80
70
60
50
40
30
20
10
FEET
1
2
3
sand
sand
finely bedded
sand. silt and clay
till 3A
till 3A
silt
clay
slumped silt
and clay
till
3C
sand
clayey
silt
silt
till
3C
0
1000
2000
3000
4000
5000
FEET

FIELD REPORT -REACH 22

Location and General Description

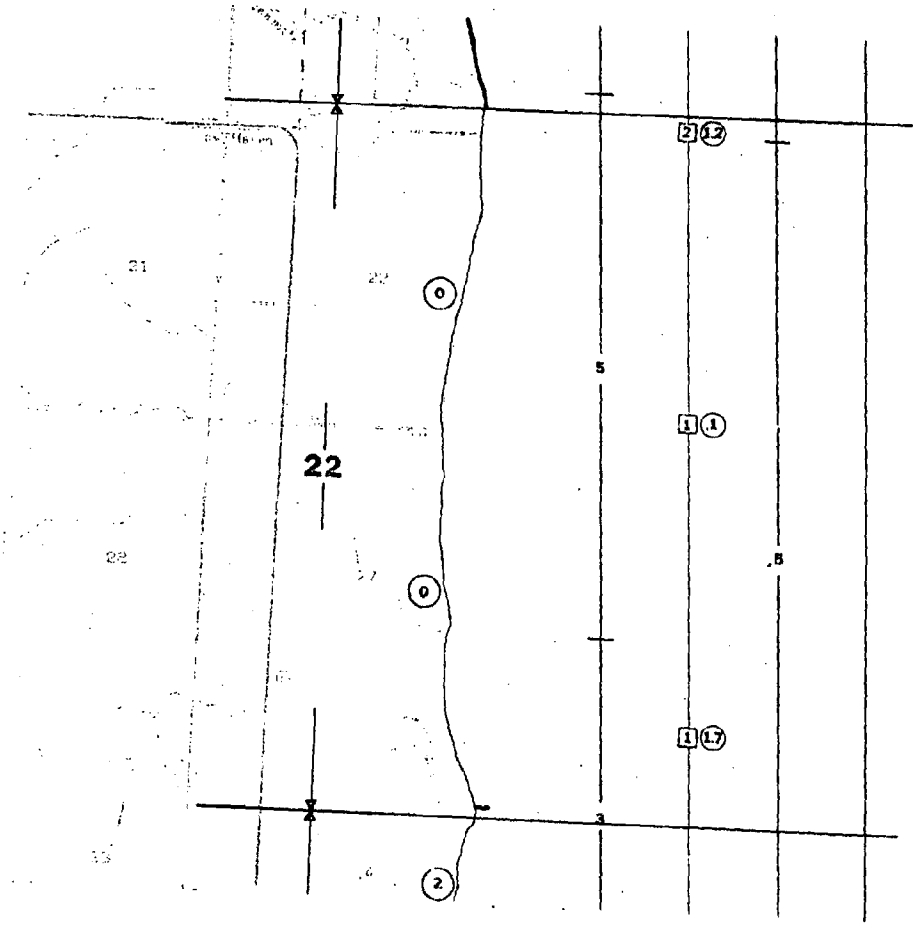
The southern boundary of Reach 22 lies in the northern third of Section 34, T. 16N. For convenience, the description of that portion of Section 34 was included with the text for Reach 21.

Reach 22 lies between miles 90.7 and 93.1 and is made up of the shoreline of the northern quarter of Section 34 and all of that along Section 27 and 22 in T. 16N., R.23E. The reach has a priority ranking of twenty-two, making it the seventh highest ranking reach in the Sheboygan-Manitowoc study area.

Land use throughout the reach is primarily agricultural, although the Wisconsin Electric Power Company has large holdings in the area and may be planning future development of a nuclear power plant.

Cobble beaches of about 20 to 30 feet are commonly found along the shoreline in this reach, and the bluff height is normally between forty-five and fifty feet.

In the immediate vicinity of the unnamed point that marks the southern boundary of the reach, the bluff is made up almost entirely of till. In an exposure near here, all three of the tills exposed in the study area may be present with no intervening lacustrine sediments. As we move northward, the normal intervening lacustrine sediments once more appear. At the south section line of Section 27, twenty feet of lacustrine sediments separate tills 3C and 3A, and till 3B is no longer present. An additional ten feet of lacustrine sediments overlie till 3C at this point. The same general stratigraphy carries northward throughout Section 27. The shoreline along this part of the coast is a relatively uniform and steep bluff. At about the south section line of Section 22, there is a sharp change in the nature of the shoreline. The steep, bare bluff found immediately to the south gives way to a series of massive slumps, some of which approach a tenth of a mile in length and are more than 100 feet from scarp



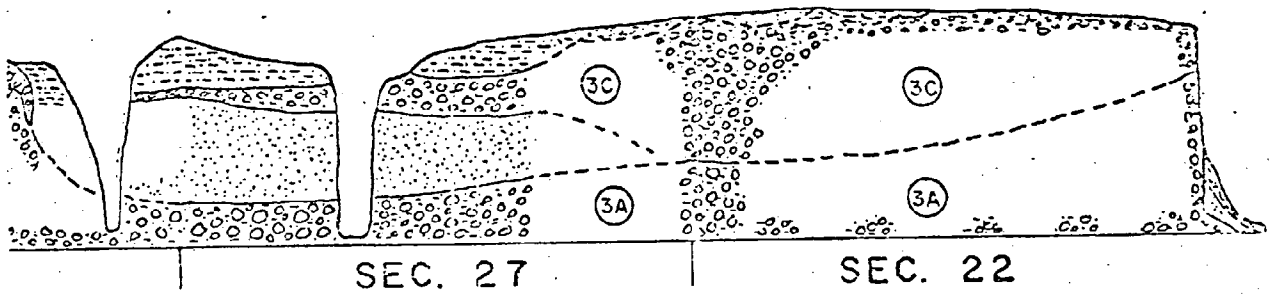
N

0 1

miles

Reach 22

PUBLIC PERCEPTION: EROSION HAZARDS { 3 Public safety, 2 Property, 1 Environment
1952 SHORE DAMAGE SURVEY -1=$10,000 (1952)
RECESSION RATES { Long-term-approx. 100 yrs., Short-term-approx. 10 yrs. } (in feet/yr.)
SHORE HEIGHT (in tens of feet)
SHORE PROTECTION STRUCTURES
HOUSES/MILE-Non-urban
BOAT RAMPS



REACH 22

1000 ft.

Vertical Exaggeration = 50 X

LEGEND

SAND	SILT	COVERED OR INACCESSIBLE
GRAVEL	CLAY	TILL
SAND AND GRAVEL	CLAYEY SILT, SILTY CLAY	MIXED SEDIMENTS

to toe. This dramatic change in mode of failure appears to coincide with a substantial decrease in the thickness of till 3A at the base of the section.

At the extreme northern end of the reach, the lacustrine sediments overlying till 3C begin to thin, becoming completely absent at the northern boundary.

Ten year average erosion rates at the southern and northern ends of the reach are 1.7 and 1.2 feet/year respectively. A somewhat anomolous figure of 0.1 foot/year was obtained for a site near the center of the reach. One hundred year average figures of 1 foot/year in the south, 1 foot/year in the center, and 2 feet/year in the northern portions of the reach were also obtained.

Section 27

From the southern section line to 0.67 the bluffs in this section are undergoing rapid erosion and the stratigraphy is fairly well exposed. The uppermost unit is a thick sequence of finely bedded sand, silts and clays. This unit attains its maximum thickness at the south section line where it is about 10 feet thick. Underlying this lacustrine sequence is a bed of till 3C which varies in thickness from about 2 feet at the southern section line to about 9 feet near the center of the section. This till is underlain by a sequence of silts and sandy silts that are relatively poorly exposed due to minor slumping and flow of the upper units. The sand and sandy silt beds range in thickness from a maximum of 22 feet at the southern section line to about 13 feet in the central portions of the section. The basal unit is till 3A of which about 2 feet is exposed throughout the section. Determination of the upper limit of this bed is quite difficult, due to the slumping and flow of the overlying sandy beds. From 0.67 to about 0.98 the mode of slope failure changes dramatically. In this area the principle mechanism of failure is large scale sequential slumping involving the entire face of the bluff. The slumping almost totally obscures the stratigraphy of the bluffs with reliable exposures present only in the

scarps along the top of the bluff. In these scarps, it was seen that the upper part of the finely bedded lacustrine sediments found to the south gives way to a deposit of sand and gravel. Exposed beds are again present from 0.98 to the northern section line. Here it is seen that the lacustrine sands and silts that separated the two tills in the area exposed to the south have pinched out, and the tills at the northern section line are in direct contact. At the section line the sequence consists of 28 feet of till 3C overlying 16 feet of till 3A.

From the southern section line to 0.14 the beaches are between 30 and 50 feet wide and composed primarily of cobbles. From 0.14 to 0.67 the beaches are still primarily cobble but are only 20 to 30 feet in width and from 0.67 to the northern section line the beaches, while still maintaining a maximum width of 30 feet are cut down in width to as little as 5 feet in scattered locations.

Land use within the section is almost entirely agricultural, with a housing density of 0. Recession rate determinations near the northern section line show a long term average rate of 1 foot per year and a short term rate of 0.1 foot/year.

Section 22

Bluff heights within this reach vary from 45 feet at the southern line to a maximum of 50 feet at about 0.5. At the north section line, the bluffs plunge into the valley of Seven Mile Creek. Almost the entire length of this section is obscured by large scale sequential slumping. Exposures are present only in a short segment at the southern section line extending northward to .08, in the scarps along the bluff top, and at scattered locations along the toe of the slope where the basal unit was exposed by wave erosion that cut through the material that had slumped down from above. At the south section line the stratigraphic sequence consisted of till 3C lying directly upon till 3A with the contact lying about 11 feet above beach level. Exposures along the bluff

top showed till 3C, overlain in spots by scattered lenses of sandy lacustrine sediments. Exposures along the beaches periodically showed till 3A exposed under the slump in the cut face.

A boring (GT-14) was taken at about 0.97. This boring showed the bluff near the northern section line to once again consist of till 3C and till 3A in direct contact. The contact between these two units was at an elevation of 34 feet above beach level at the boring site.

Cobble beaches, ranging in width from 5 to 35 feet, were found along this section. Land use was almost entirely agricultural with a housing density of 0. The land, however, is owned by the Wisconsin Electric Power Company and is being considered as a potential future site for a nuclear power plant.

Recession rate measurements taken near the northern section line showed a long term recession rate of 2 feet/year and a short term average of 1.2 feet/year. At the site of GT-14, the water depth 50 feet from the shoreline was approximately 1.5 feet, and at the site of Profile #1, the water was 1.8 feet deep, 50 feet from the shore.

University of Wisconsin--Extension

Geological and Natural History Survey

1815 University Avenue, Madison, Wisconsin 53703

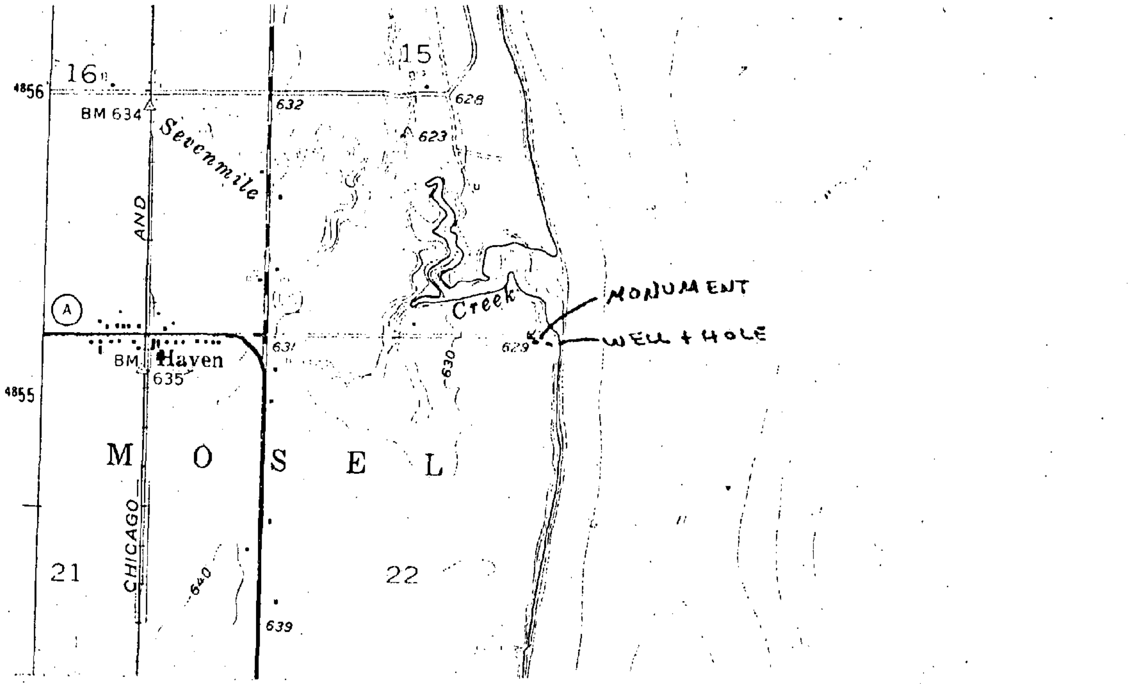
LOCATION AND MONUMENTATION SKETCHES

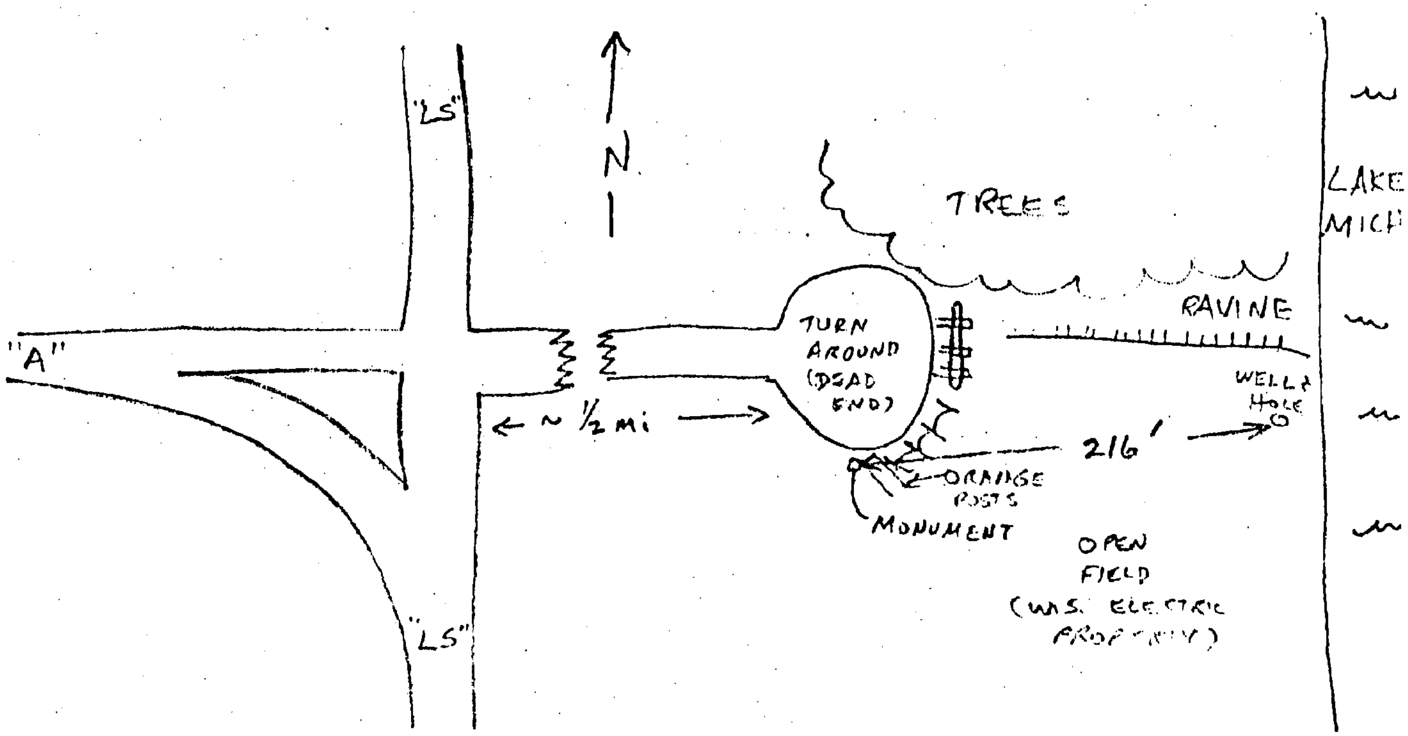
Boring No. GT-14, Wis. Electric Property, Sheboygan Co., near [illegible]

N½ / Sec. 22 / T. 16 N. / R. 23 E. Sheboygan North Quad

Date

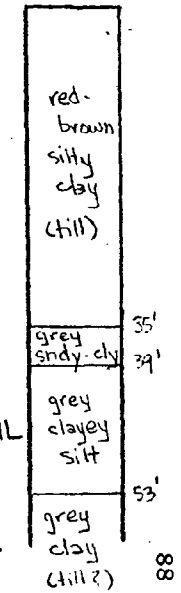
Drawn by



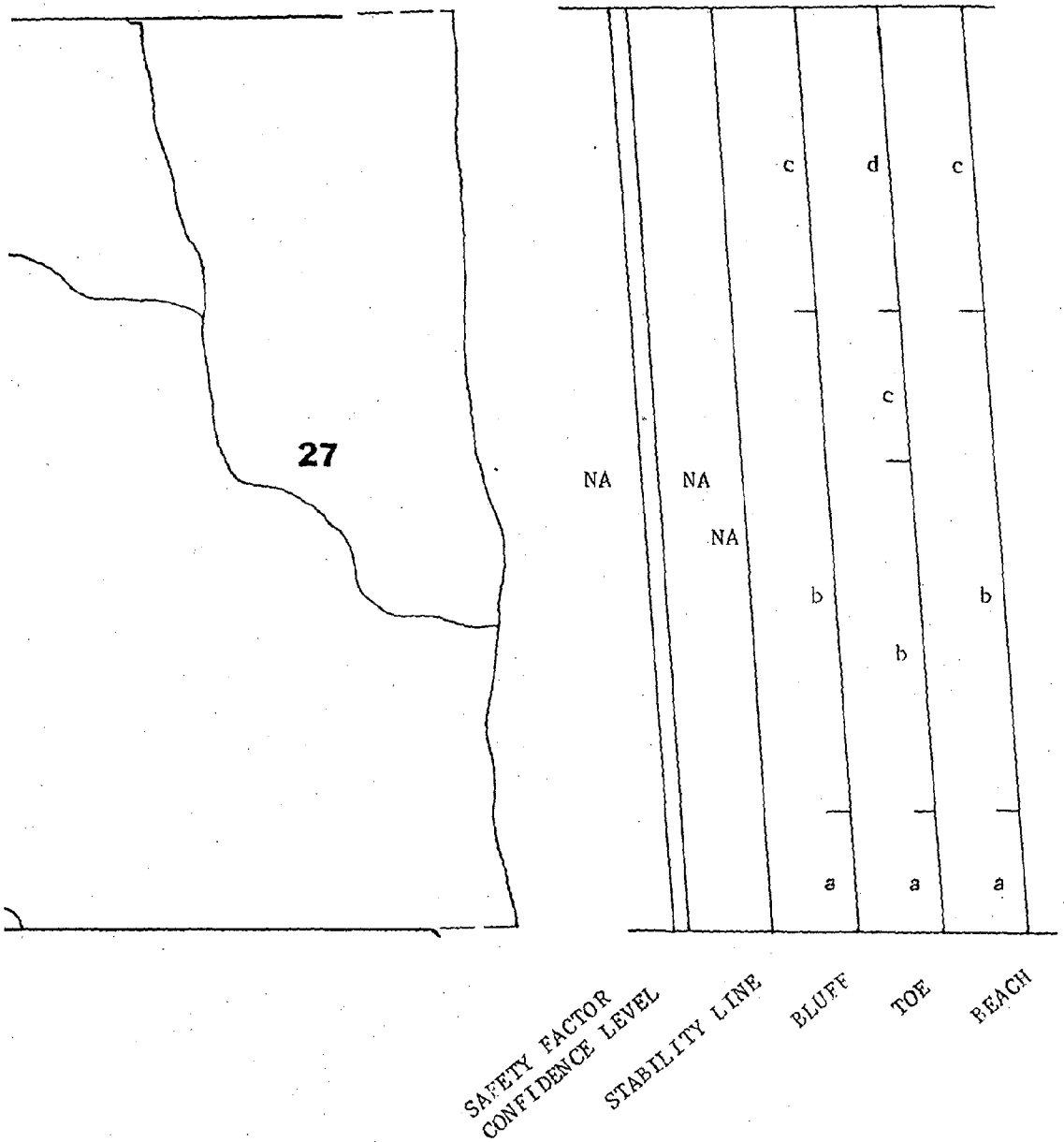


Borehole: GT-14 Location: Wis. Electric Co., Sheboyban County, Sec. 22, T16N

Depth (feet)	Blow Counts (split spoon) Standard Penetration	Pocket Penetrometer	w_n %	γ_d (psf)	w_L %	I_P %	% Clay	% Clay & Silt	$\phi°$	c (psf)	c_{vane} (psf)	USCS class.
5					23.8	11.8		69.7				
			10.4		24.1	11.8						
10			14.5	120	31.5	14.4			29.9	471	>4175	
15			15.0	122	31.0	15.7	40.0	97.5	29.9	471	2800	CL
20												
25			18.0	114	28.3	13.6	35.8	91.9	29.9	471		
30												
35			19.6	110	35.5	19.1						
40					30.3	16.6						CL
45			15.8	130	25.6	11.0	30.4	97.4				
50					21.4	7.3						CL-ML
55			25.3	102	35.3	17.6	51.7	99.9	22.3	1023		
60					37.5	21.5						CL



T.16N.,R.23E.,Sec.27



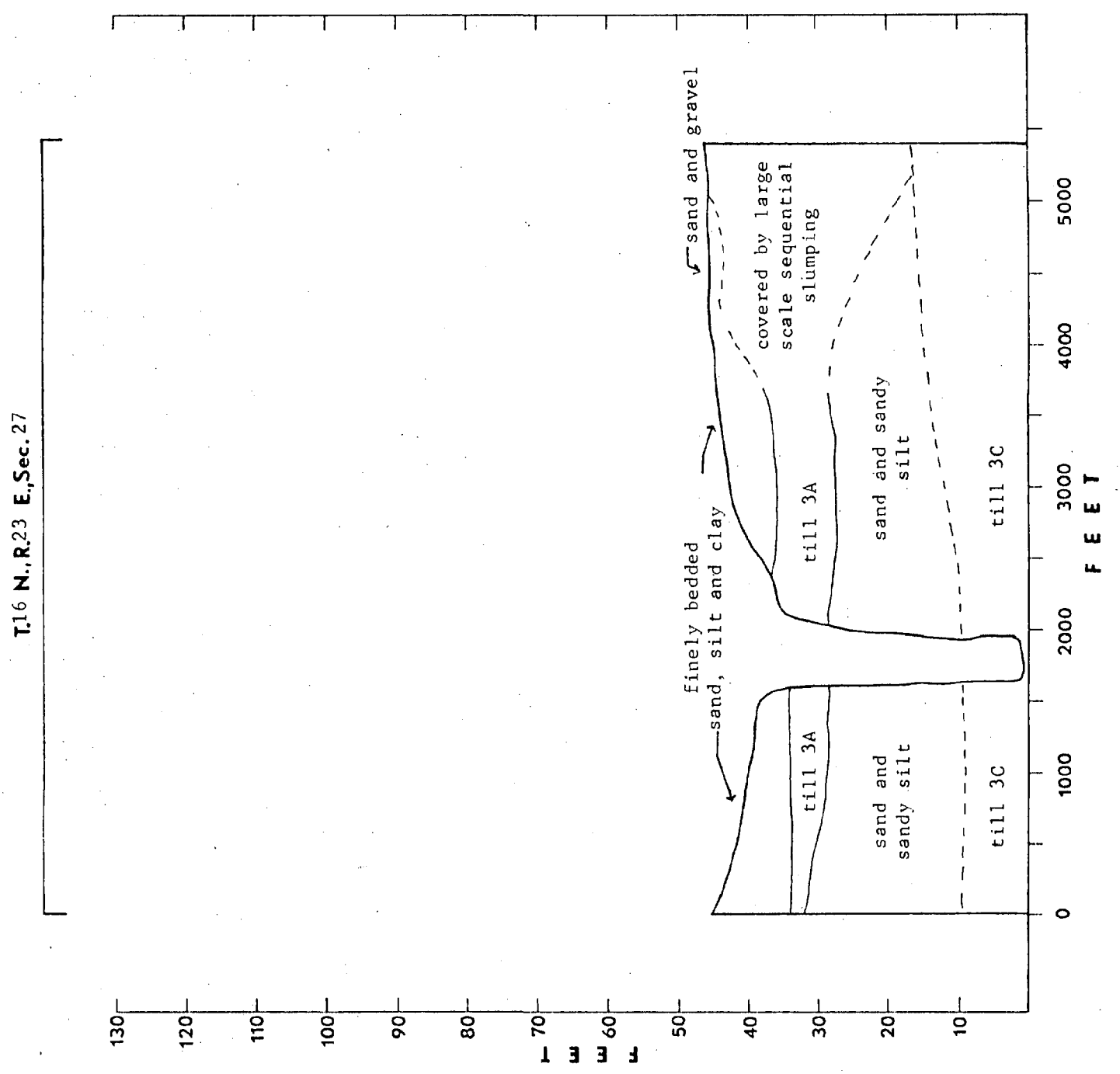
SAFETY FACTOR

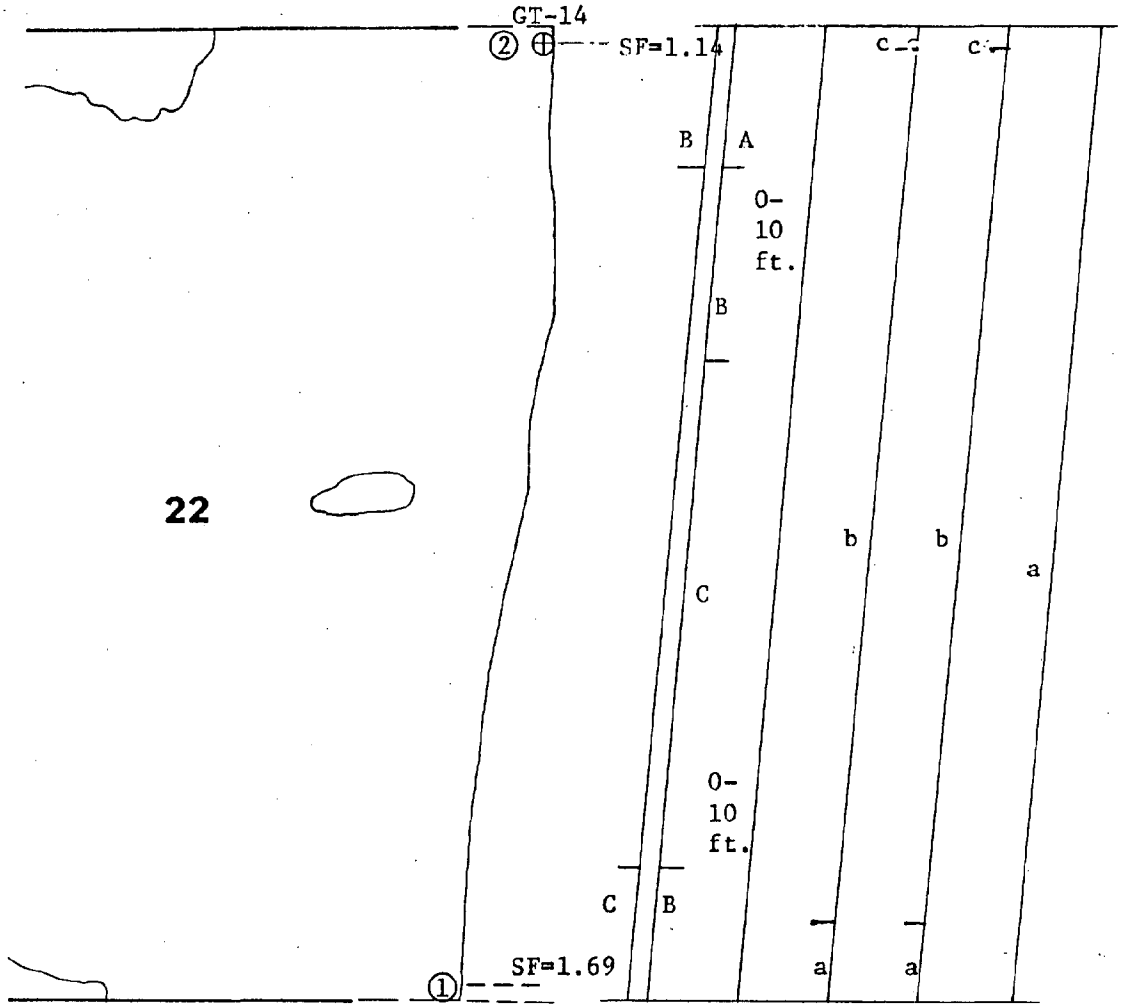
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	a-steep actively eroding slope, sapping and soil fall major mechanisms near toe, some flows and minor slumping above	b-steep actively eroding slope slumping and soil fall primary factors	c-large scale slumping involving total face; some secondary slumps and flows	
2. TOE	a-till '3C'	b-till '3C' and slumped till '3C'	c-slumped till '3C', sand, and silt	d-slumped till '3A'
3. BEACH	a-30-50 ft. cobbles	b-20-30 ft. cobbles	c-5-30 ft. cobbles	


T.16 N., R.23 E., Sec. 27
FEET
130
120
110
100
90
80
70
60
50
40
30
20
10
FEET
0
1000
2000
3000
4000
5000
sand and gravel
covered by large scale sequential slumping
till 3A
sand and sandy silt
till 3C
finely bedded sand, silt and clay
till 3A
sand and sandy silt
till 3C



SAFETY FACTOR

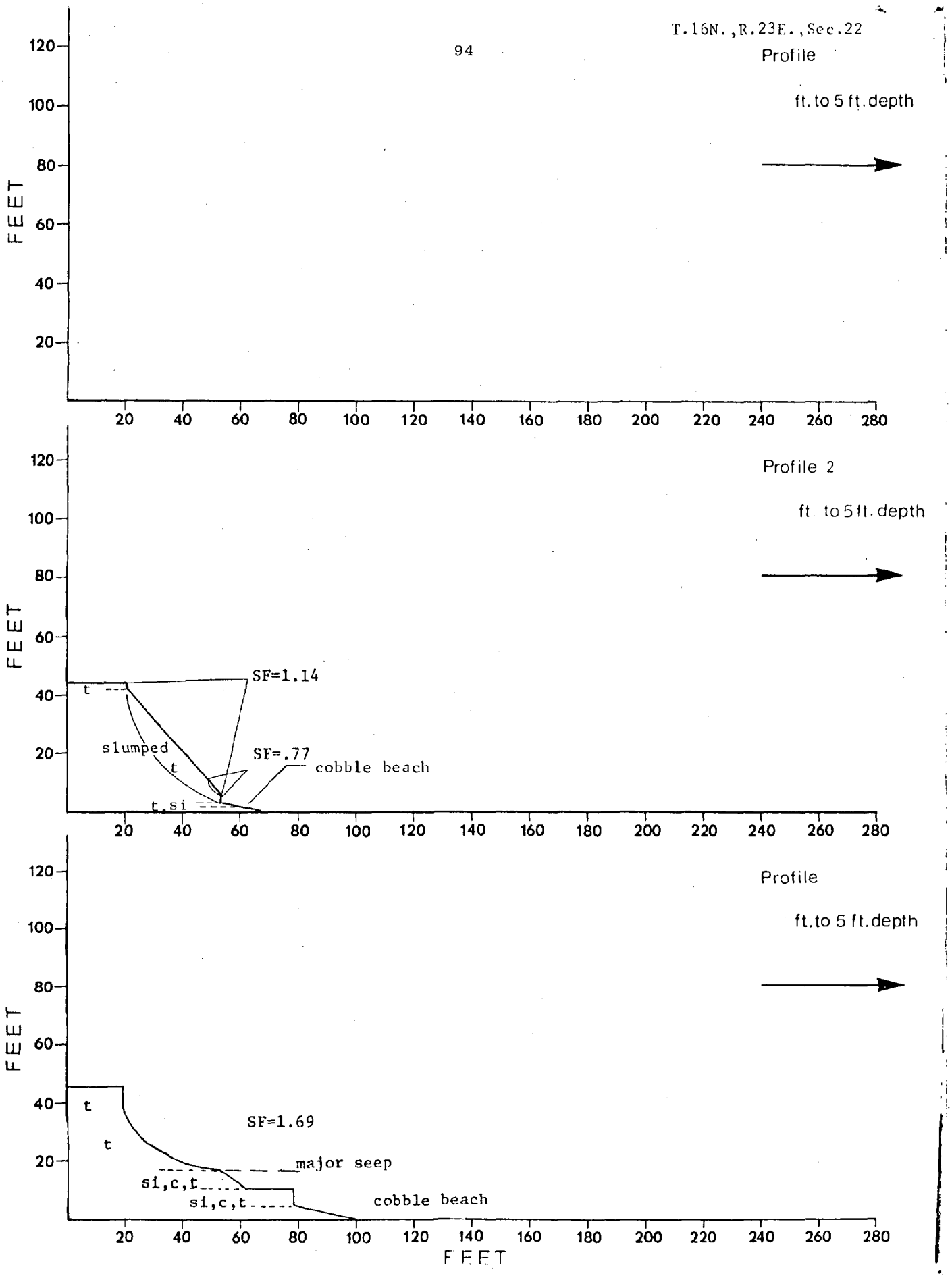
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

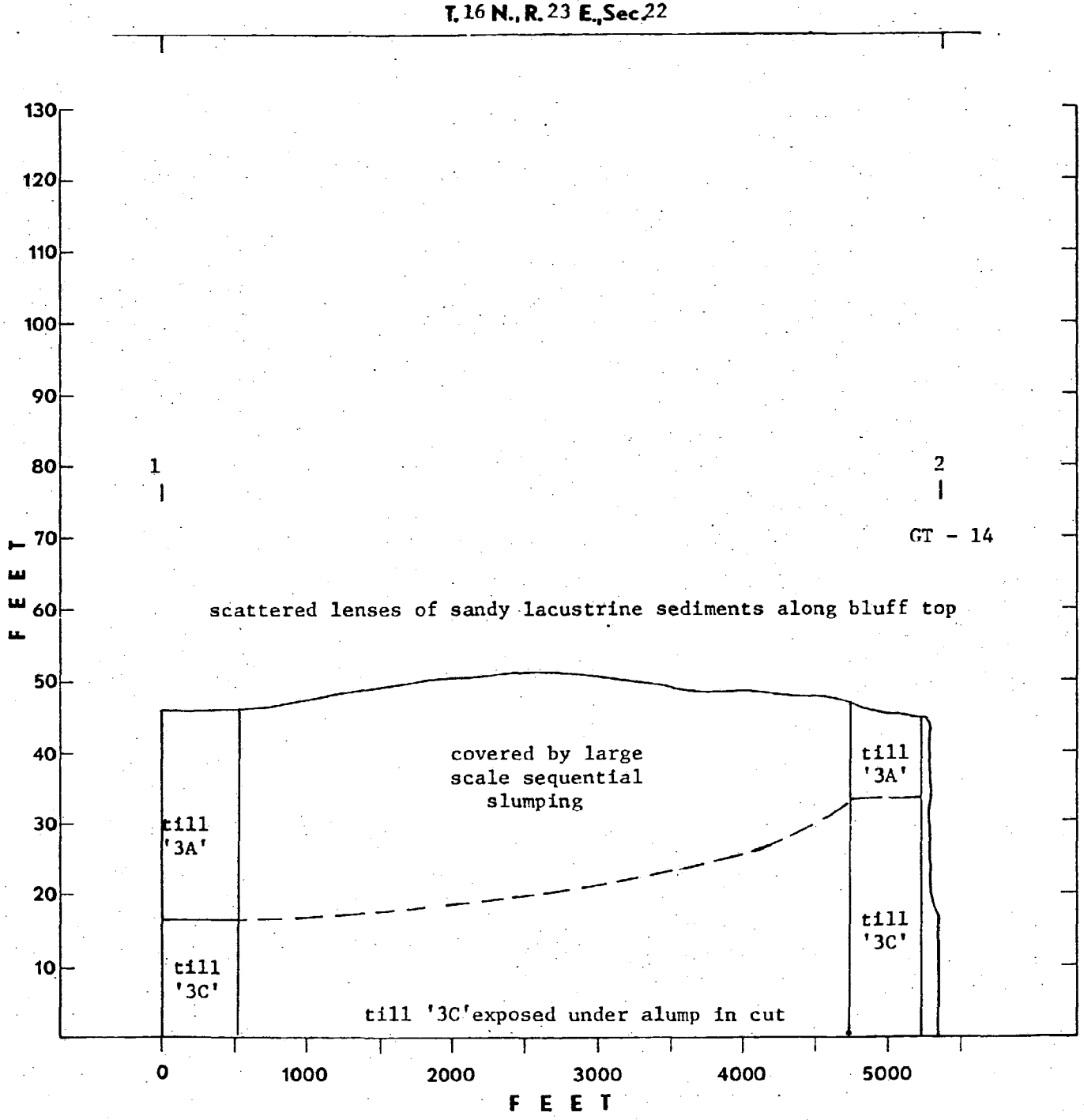
CONFIDENCE LEVEL

A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

T.16N.,R.23E.,Sec.22

1. BLUFF	a-steep actively eroding slope; soil fall major factor	b-large scale sequential slumping of entire face	c-steep actively eroding slope, soil fall major factor
2. TOE	a-till '3C'	b-till '3C' and slumped till '3A'	c-till '3C'
3. BEACH	a-5-35 ft. cobbles		


T.16N.,R.23E.,Sec.22
Profile
ft.to 5 ft.depth
FEET
120
100
80
60
40
20
20 40 60 80 100 120 140 160 180 200 220 240 260 280
Profile 2
ft. to 5 ft. depth
SF=1.14
t
slumped
t
SF=.77
cobble beach
t,si
Profile
ft.to 5 ft.depth
t
t
SF=1.69
major seep
si,c,t
si,c,t
cobble beach
FEET


T. 16 N., R. 23 E., Sec. 22
130
120
110
100
90
80
70
60
50
40
30
20
10
FEET
1
2
GT - 14
scattered lenses of sandy lacustrine sediments along bluff top
covered by large scale sequential slumping
till '3A'
till '3C'
till '3A'
till '3C'
till '3C' exposed under alump in cut
0
1000
2000
3000
4000
5000
FEET

FIELD REPORT - REACH 23

Location and General Description

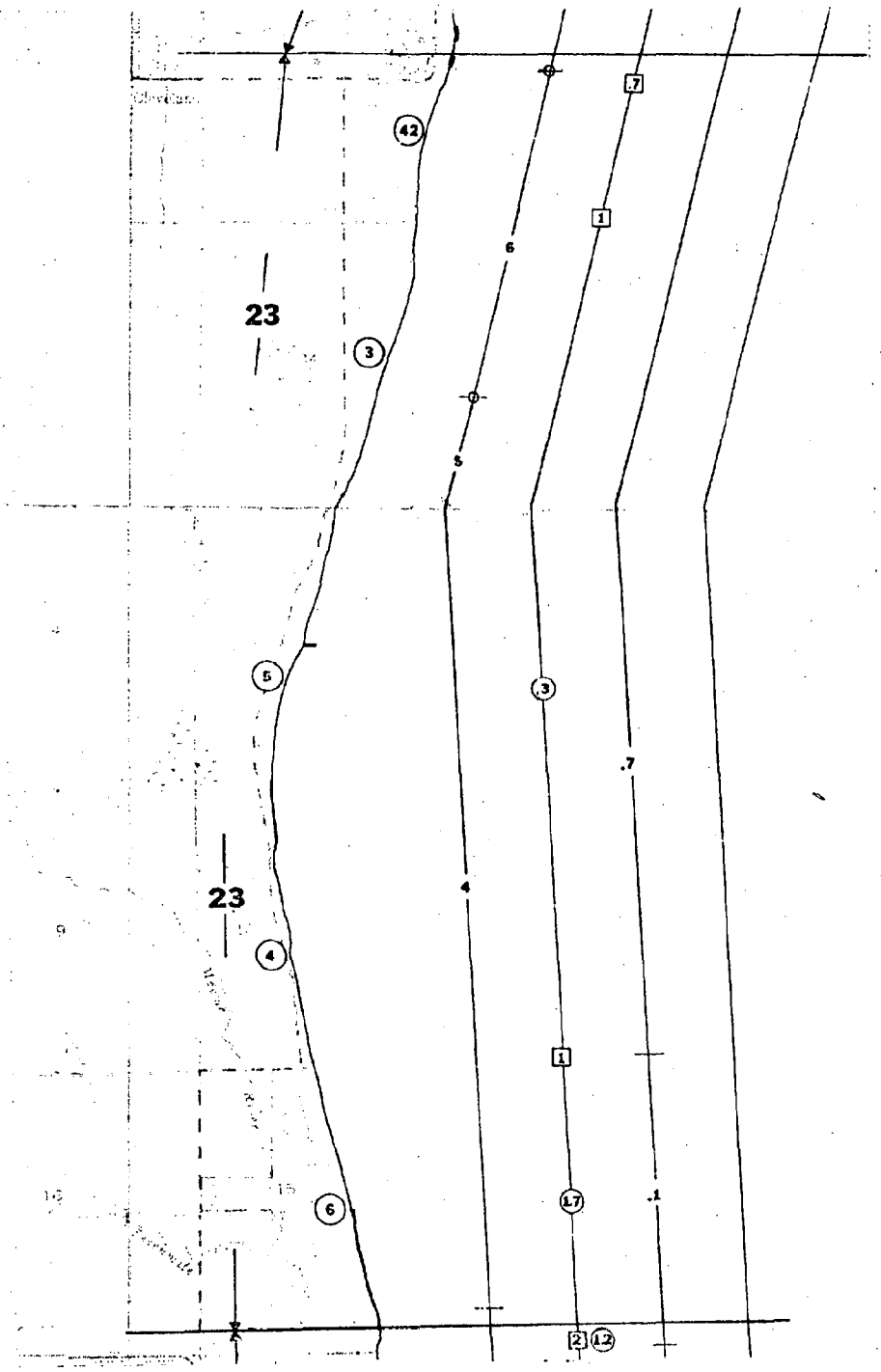
Reach 23 lies in Sheboygan and Manitowoc Counties and includes the shoreline in Sections 10, 15, and 3 in T.16N., R.23E., and of Section 34 and a portion of Section 27 in T.17N., R.23E. This is the area lying between Seven Mile Creek and Centerville Creek. The reach has a priority ranking of 23, and is the eighth most highly ranked reach in the area north of Ozaukee County.

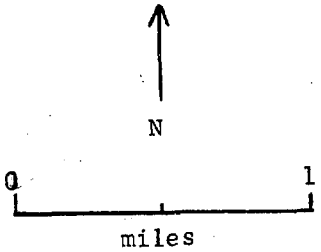
With the exception of the town of Cleveland, which lies at the extreme northern end of the reach, the shoreline is almost exclusively agricultural land. Average density of dwelling within the reach, excluding the Cleveland area, is less than 5 homes per mile.

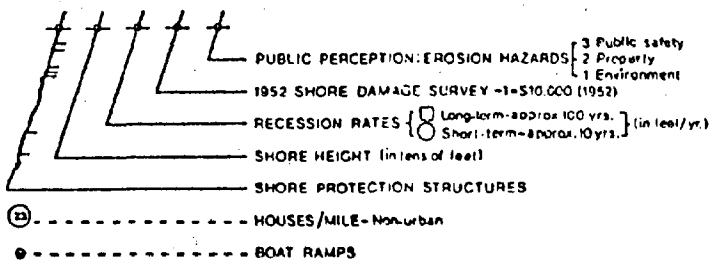
At the southern boundary of the reach, the bluff plunges sharply into the valley of Seven Mile Creek. North of the valley, which is about 1000 feet wide, the bluff once again rises steeply, attaining a height of about 50 feet. The bluff is very uniform north from this point, showing a very slow rise to the north where it reaches a height of almost 60 feet before reaching the valley of Centerville Creek at Cleveland. Throughout the reach, beaches are predominantly of cobbles, and normally 20 to 30 feet in width.

Immediately to the south of the Seven Mile Creek, till 3C is roughly 10 feet thick, and lies directly on the surface of till 3A. Just north of the valley, till 3C is absent and the erosion surface that marks the top of till 3A is within 5 feet of the bluff top under a thin cover of silty and sandy lacustrine deposits. Moving northward, the surface of till 3A makes a slow and irregular descent with the overlying lacustrine sediments showing a commensurate increase in thickness. The contact is, however, extremely irregular throughout the reach.

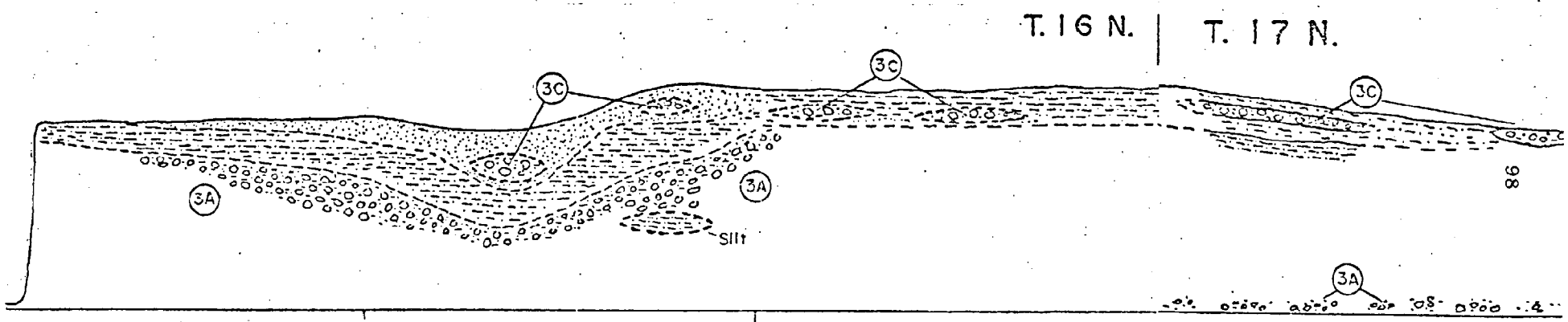
Till 3C once again appears in Section 10 of T.17N., R.23E. Rather than being present as a persistent bed, it occurs as lenses of till completely surrounded by


23
23
42
3
5
4
6
7
1
6
5
3
.7
4
1
1.7
.1
2
1.2


N
0
1
miles


PUBLIC PERCEPTION: EROSION HAZARDS
3 Public safety
2 Property
1 Environment
1952 SHORE DAMAGE SURVEY -1=$10,000 (1952)
RECESSION RATES
Long-term-approx 100 yrs.
Short-term-approx. 10 yrs.
(in feet/yr.)
SHORE HEIGHT (in tens of feet)
SHORE PROTECTION STRUCTURES
HOUSES/MILE-Non-urban
BOAT RAMPS

REACH 23



REACH 23

1000 ft.

Vertical Exaggeration = 50 X

LEGEND

SAND	SILT	COVERED OR INACCESSIBLE
GRAVEL	CLAY	TILL
SAND AND GRAVEL	CLAYEY SILT, SILTY CLAY	MIXED SEDIMENTS

sandy sediments in the upper portion of the lacustrine sequence. This is thought to be the mode of occurrence of the upper till throughout the remainder of the reach.

Despite the abrupt change in stratigraphy that occurs at the south end of Reach 23, the slope failures along the shoreline continue to be in the form of very large scale slumping with the resulting slump blocks of the type found in the northern portions of Reach 22. This type of failure makes the study of the stratigraphy through this reach extremely difficult, since very little of the stratigraphic sequence is exposed.

Only two ten year recession rate determinations were available for Reach 23; the southernmost of which was 1.7 feet/year, and the other, which was taken in Section 3, was 0.3 foot/year. The one hundred year average recession rates for the reach were about 1 foot/year.

Section 15

At the southern section line the bluffs are plunging sharply into the valley of Seven Mile Creek. A sequence of 4 feet of silty alluvium, overlying 6 feet of sand and gravel, over 5 feet of till 3A was observed in an exposure at the section line. The bluffs returned to their full height at the northern side of the valley at about 0.16. At this point the bluffs are about 50 feet high. Northward from this point to about 0.44 the toe of the slope is protected by a heavy dolomite block revetment and the slope behind is fully covered and grassed. Although some slumping has begun in this section it has, for the most part, been stabilized by the structure and vegetative cover. A brief sequence of beds is, however, exposed in an old scarp near the northern valley wall of Seven Mile Creek and Profile #1 was taken at this location. Here it was seen that the upper portion of the bluff was made up of about 5 feet of lacustrine silt on the surface of till 3A. From 0.44, which is the northern end of the revetment, the shoreline is

undergoing active erosion. Slope failures are in the form of large scale sequential slumps and the stratigraphy from the end of the revetment to the north section line is almost totally obscured. Examination of scattered exposures along the scarps at the top of the bluff showed, however, that at about 0.45 a sandy lacustrine phase appeared over the silty lacustrines that were previously described, and that the contact of the fine grained lacustrines with the underlying till 3A dips slightly towards the north.

The beach south of the revetment and in the vicinity of Seven Mile Creek was found to be 15 feet to 35 feet wide and to consist primarily of pebbles and cobbles. North of the revetment, the beach was 10 to 40 feet wide and was a cobble beach. In many areas, slumps had moved out into the water in the recent past and the beach zone was made up of residual till.

Although current land use along the shoreline section is predominantly agricultural, this area was apparently the past site of a Nike missle base, and the grass landing strip running parallel to the shoreline is still used upon occasion. Housing density for the section is given as 6 houses per mile. Most of this development is, however, well inland from the shoreline.

A long term erosion rate measurement was available for a point near the southern section line and listed the long term average rate as 2 feet/year. A short term measurement at the same site gave an average of 1.2 feet/year and an additional short term reading near the center of the section gave a reading of 1.7 feet/year.

Section 10

The large scale slumping that was noted in the section to the south continued throughout most of Section 10. There were, however, scattered locations in which relatively good exposures could be found and in addition a boring (GT-13) was taken in the middle of the section. On the basis of this information it was

possible to trace the geology of the bluff through at least the southern 0.8 of the section, although in many places the exact location of the contacts is in considerable doubt.

At Profile #1, which was taken several hundred feet north of the south section line, the stratigraphy was found to consist of about 6 feet of sandy lacustrine sediments overlying roughly 10 feet of predominantly silty deposits which in turn overlay till 3A. At the southern section line the contact with till 3A was about 34 feet above beach level and the bluffs were roughly 50 feet high. From this point the beds appeared to dip gently to the north presumably following a low in the erosion surface on till 3A. At boring GT-13 the upper surface of the till had dropped to an elevation of 20 feet. The stratigraphy in this boring was essentially the same as that exposed near the southern section line except for the fact that an 8 foot bed of till 3C was encountered within the upper sandy lacustrine phase. Examination of the upper protion of the bluffs near the boring site showed the till bed to be in a lens incorporated within the upper sandy unit. In the course of investigating the section, several additional lenses of this type were encountered. These till lenses are shown diagrammatically on the longitudinal profile for this section. From this area northward, till 3C has been found to normally be intimately associated with sandy deposits similar to those found in this section. Northward along the bluffs from the site of GT-13, the erosion surface on the till was found to rise once again until at Profile #3 which was taken at 0.78, contact between the till and overlying silty lacustrines was about 40 feet above beach level. Another lens of till 3C was found within the upper sand units at Profile #3 and a lens of water bearing silt was found within the body of till 3A. North of the exposure at which Profile #3 was taken, slumping becomes much more severe and large multiple sequential slumps effectively mask the stratigraphy to the northern section line.

Beaches throughout this section are composed of cobbles and vary in width from 5 feet to a maximum of about 20 feet. Water depths were determined at the sites of Profiles #2 and #3. At Profile #2 the water was 2 feet deep 50 feet from the shoreline while at Profile #3 it was about 3.5 feet deep.

Housing density was listed as 4 houses per mile, although these figures are somewhat misleading, since most of the development is in the shore zone. No recession rate measurements were available for this section.

Section 3

The shoreline along this section is typified by large scale sequential slumping that involves essentially the total face of the bluff. As a result of this slumping, there are few exposures of the bluff materials in place and study of the stratigraphy of the bluffs is extraordinarily difficult. Inspection of the scarps along the bluff tops shows lacustrine sand, silts, and silty clay, poorly exposed at intervals along the top of the bluff. Till 3C was exposed in, and in some cases under, these lacustrine sediments in the form of small and discontinuous lenses. Till 3C was also very prominent in the slumped material along the beaches. No exposures of the lower till, till 3A, were found in this section. Cobble beaches were found from the southern section line to about 0.8. These beaches average roughly 30 feet in width, although they pinch down to as little as one foot in the vicinity of recent slumps. From 0.8 to the northern section line the beaches were 5 to 30 feet wide and were a combination of sand and cobbles. Between about 0.85 and 0.95 there were large numbers of boulders along the beach.

Housing density was listed as 5 houses per mile. One short term recession rate measurement had been made at about 0.4 and showed an average annual rate of 0.3 foot/year. Water depth 50 feet from shore was found to be 3 feet at the site of Profile 31 at about 0.9. No protective structures were described.

Section 34

This section lies in Manitowoc County and is, therefore, described in Appendix 6.

University of Wisconsin--Extension 104
Geological and Natural History Survey
1815 University Avenue, Madison, Wisconsin 53703

LOCATION AND MONUMENTATION SKETCHES

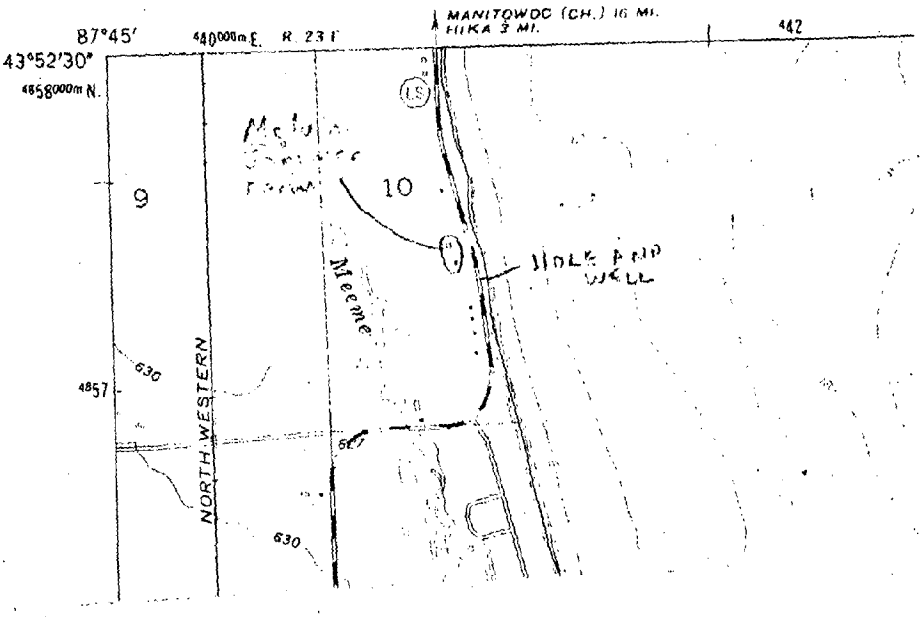
GT-13, Sommer Farm north of Sheboygan (6 mi); Sheboygan Co.

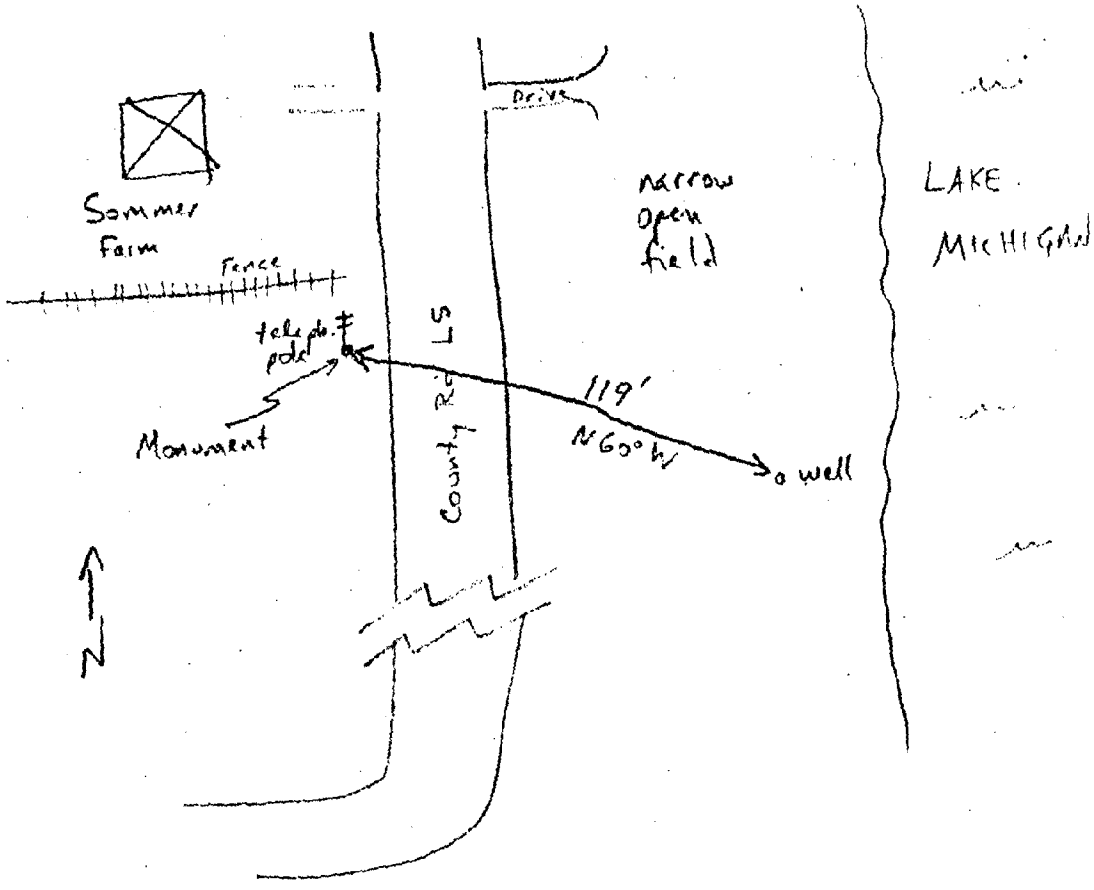
Boring No.

SW 1/4 | Sec. 10 | T. 16 N. | R. 23 E.

Date

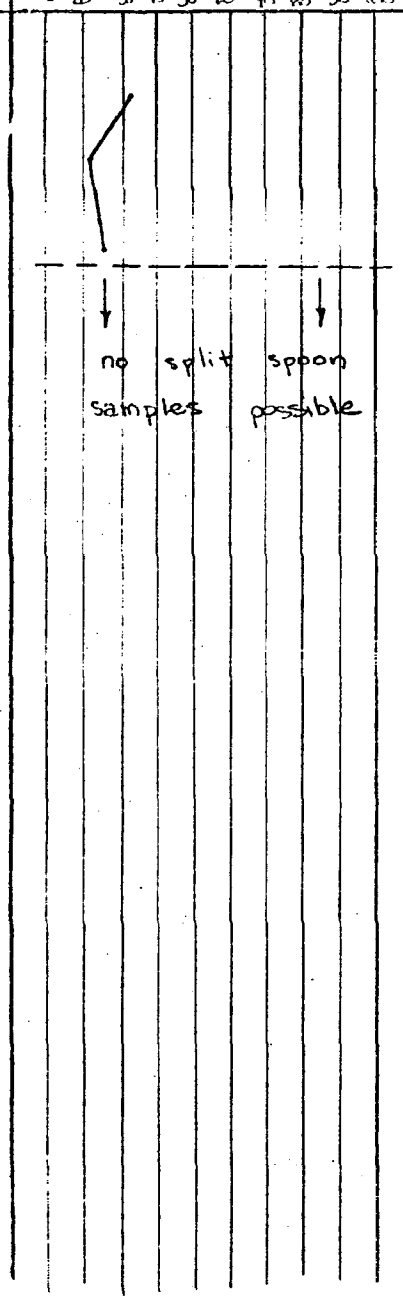
Drawn by

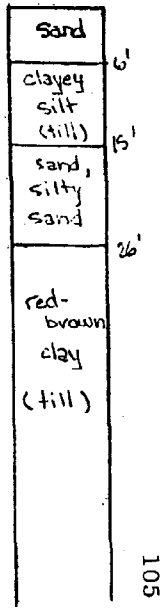


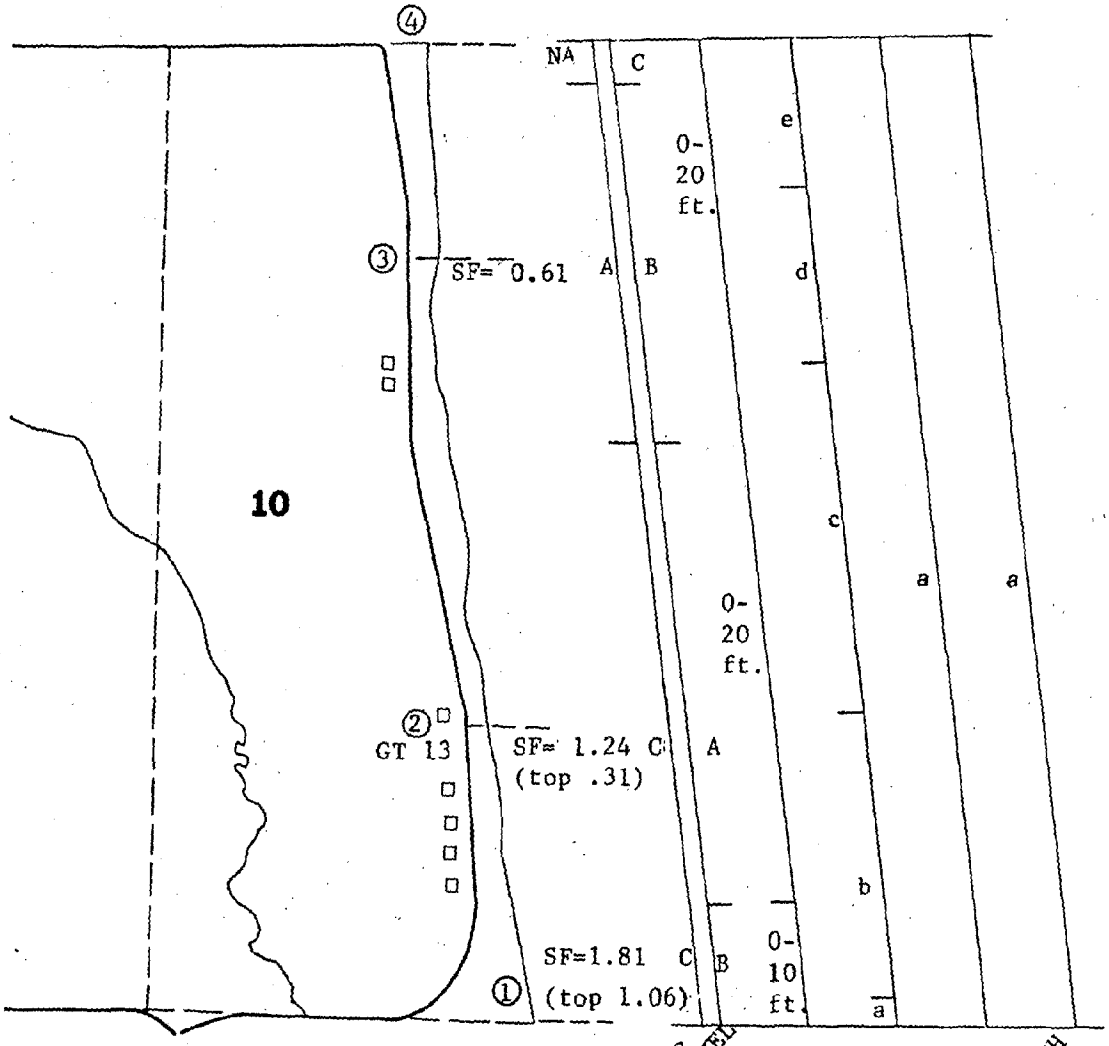


Borehole: GT-13 Location: Sommer Farm, Sheboygan County, Sec. 10, T16N

Depth (feet)	Blow Counts (split spoon) Standard Penetration	Pocket Penetrometer	w_n %	γ_d (psf)	w_L %	I_P %	% Clay	% Clay & Silt	$\phi°$	c (psf)	c_{vane} (psf)	USCS class.
5			8.6	94	(sand)							SP
			13.1	119	20.1	6.8			34.0	0	2619	
10												CL
15			15.8		22.2	11.4	23.2	68.6				
20												SW
25			20.3	109	23.3	7.1			34.0	0		
30					29.0	15.5						
35					42.3	23.4						
40					33.8	17.2						CL
45												
50					35.2	18.4						
55												
60					38.1	20.7						





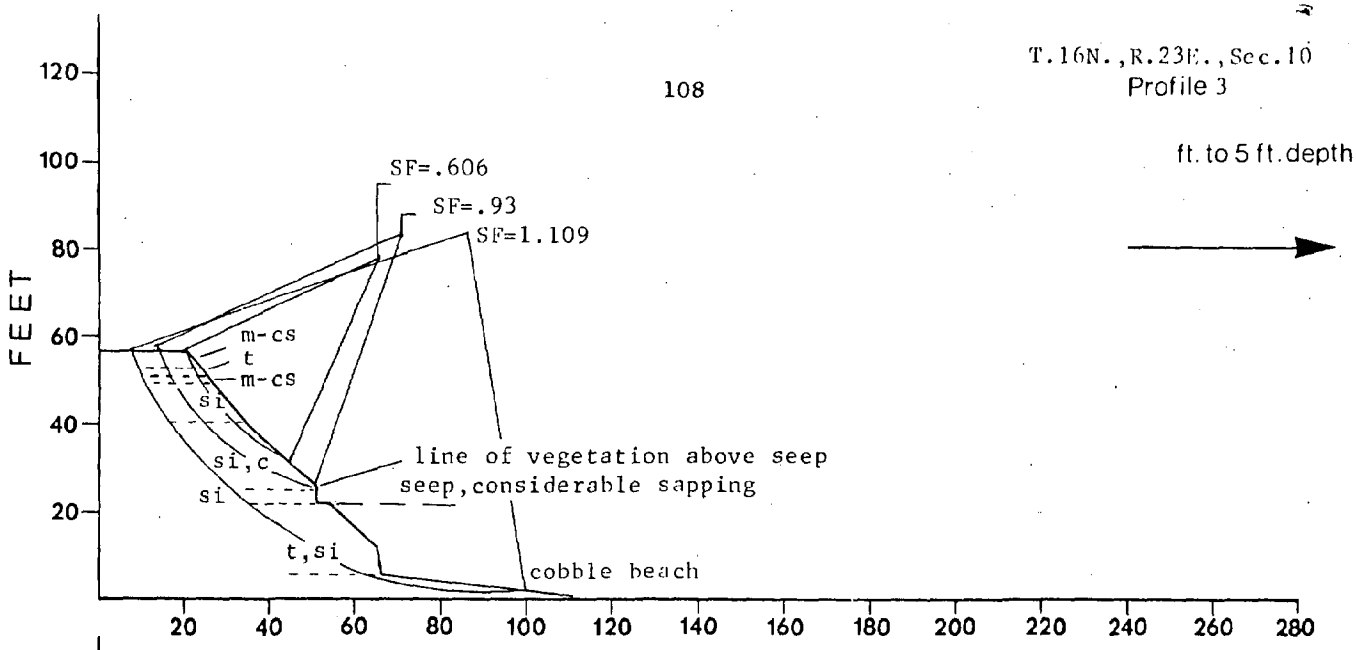


SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

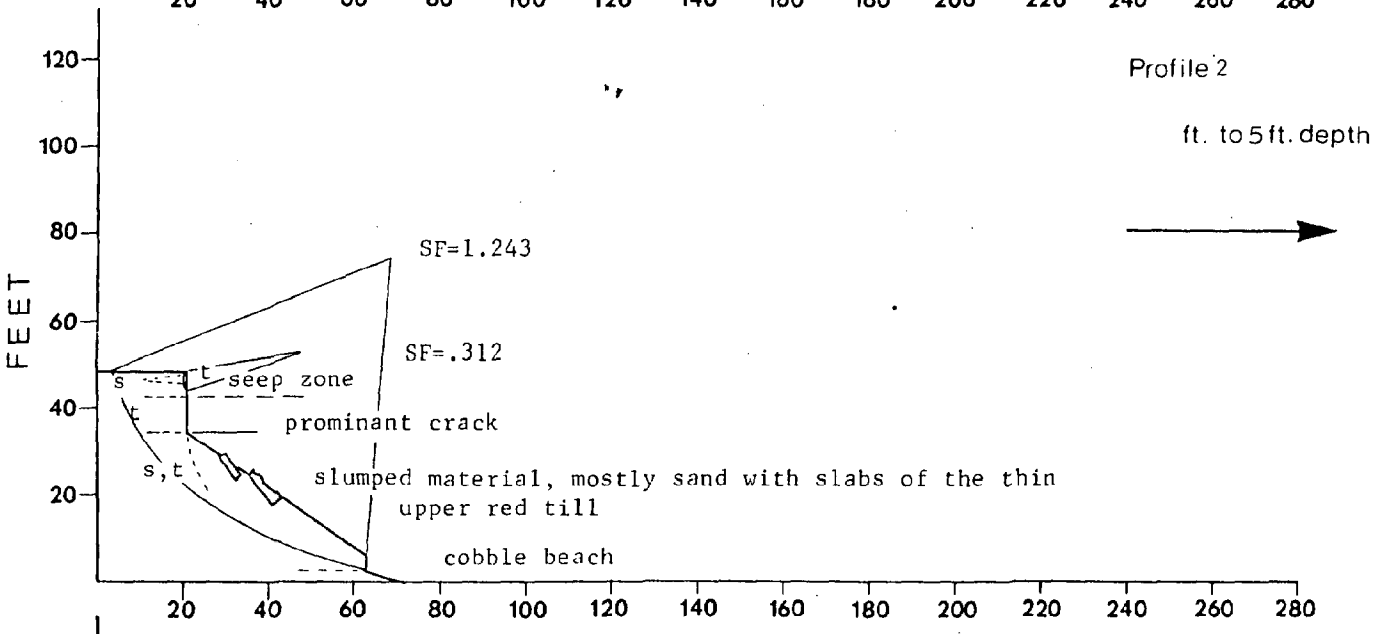
CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	a-large scale, full slope slumping; slump blocks up to several hundred feet normal to the lake, and extending laterally for as much as a tenth of a mile; the slump blocks are fully vegetated with grasses, shrubs, and trees of up to forty feet in height; scarps at the head of the slump blocks are about 20 ft. high and unvegetated.	b-rapid erosion is indicated by very steep bluffs, normally about 20% vegetated with grasses; the slumps are closely spaced, and much of the slumped material has been removed through shoreline erosion.
	c-very similar to 'a'	d-similar to 'b', although slump blocks are somewhat larger, and in many cases have retained their vegetative cover.
	e-conditions very similar to 'a' and 'c'.	
2. TOE	a-throughout the section, toe is a cut face in slumped till, and to a lesser extent, lacustrine silts.	
3. BEACH	a-beach essentially uniform, averaging about 25 ft. in width except where locally constricted by slides; largely a cobble beach, with scattered, small, and highly localized areas of coarse sand to lakeward.	
4. STRUCTURES-none		

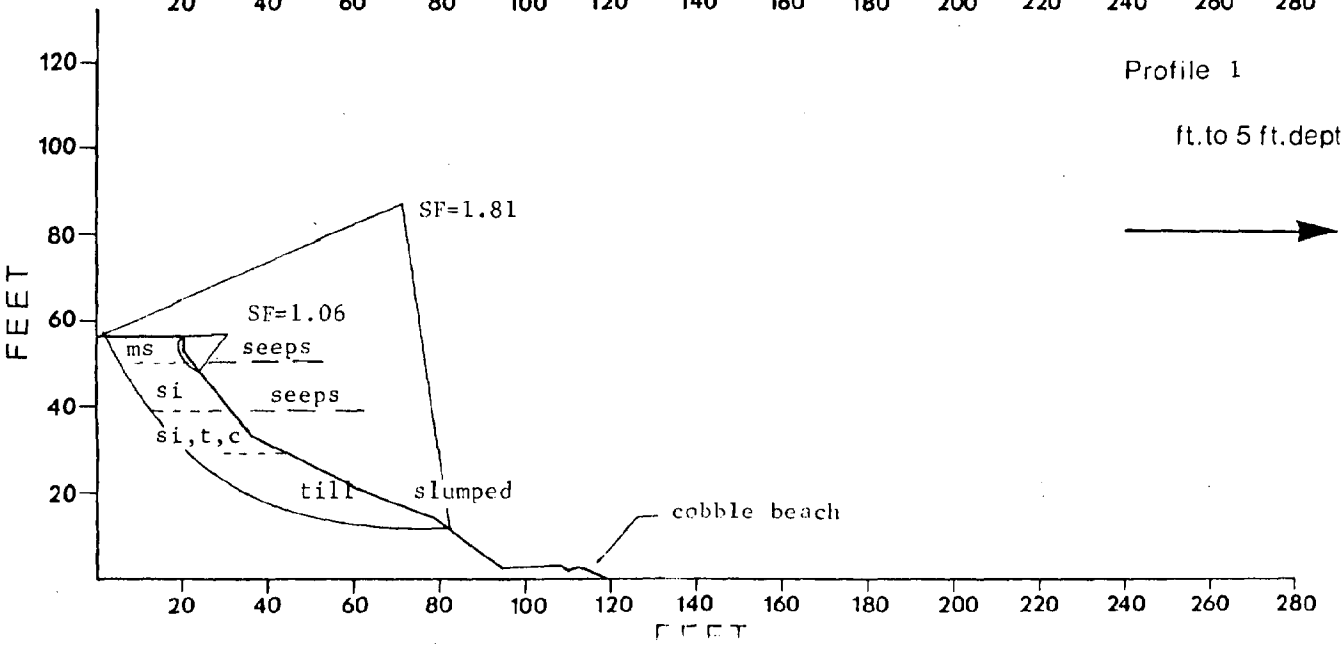
T.16N.,R.23E.,Sec.10
Profile 3



Profile 2



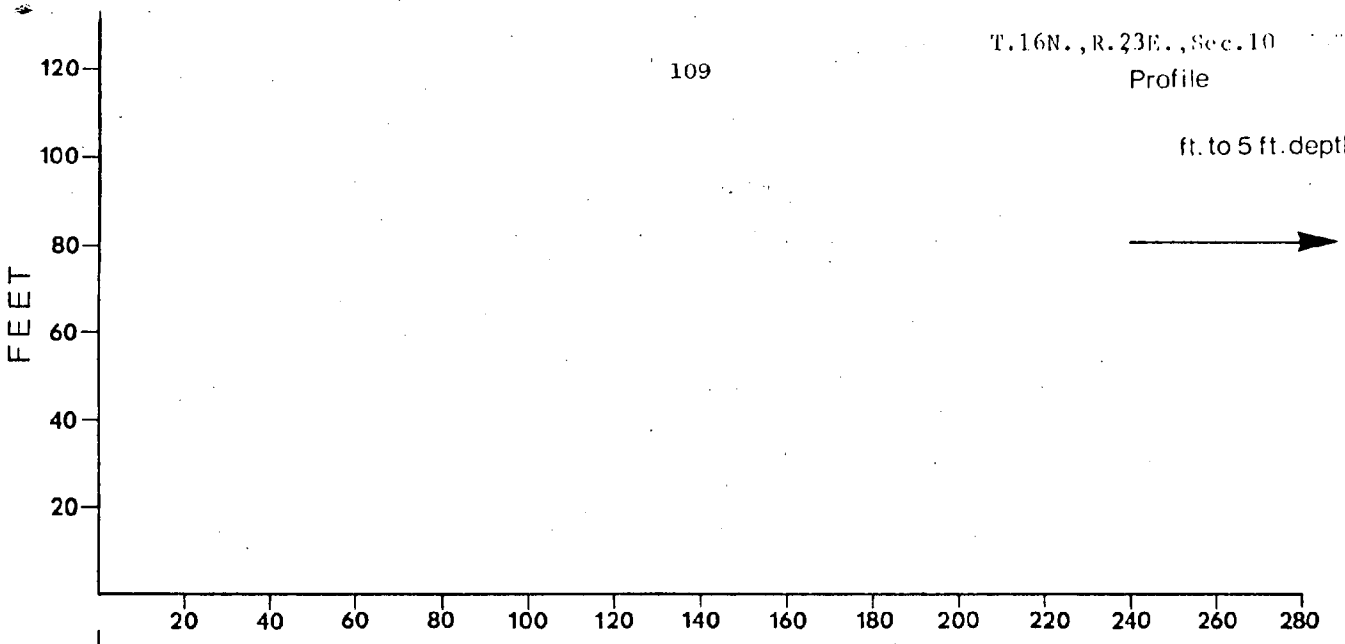
Profile 1



T.16N.,R.23E.,Sec.10

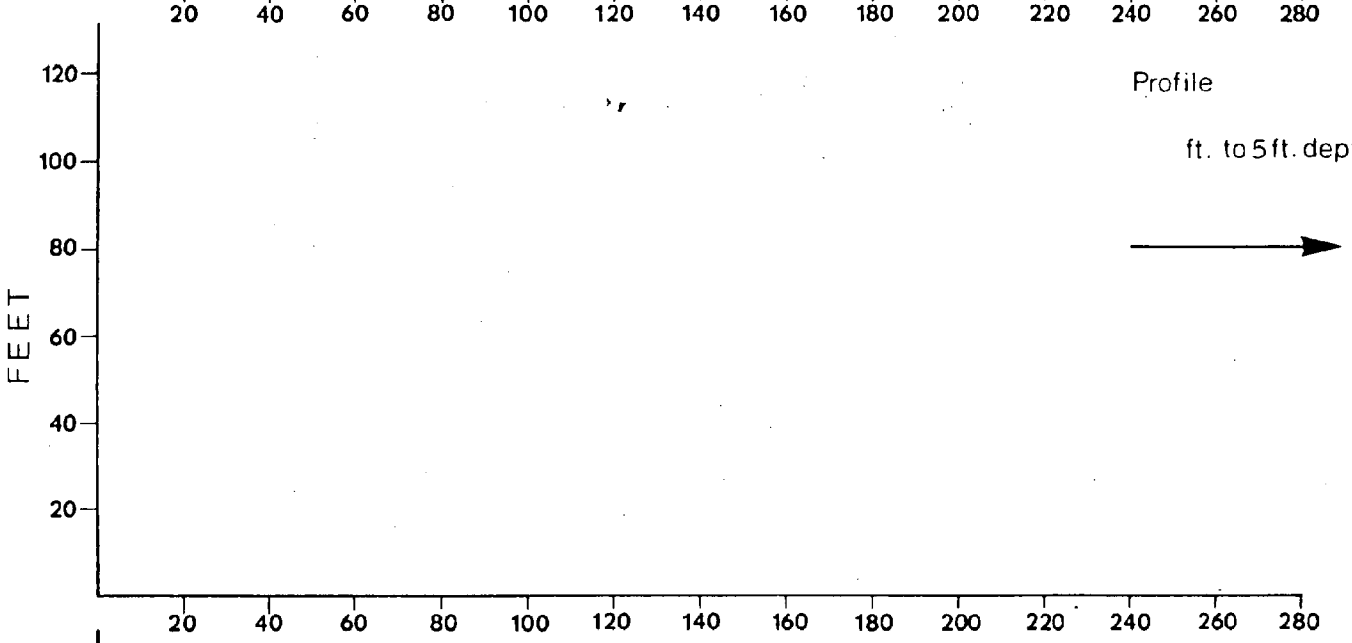
Profile

ft. to 5 ft. depth



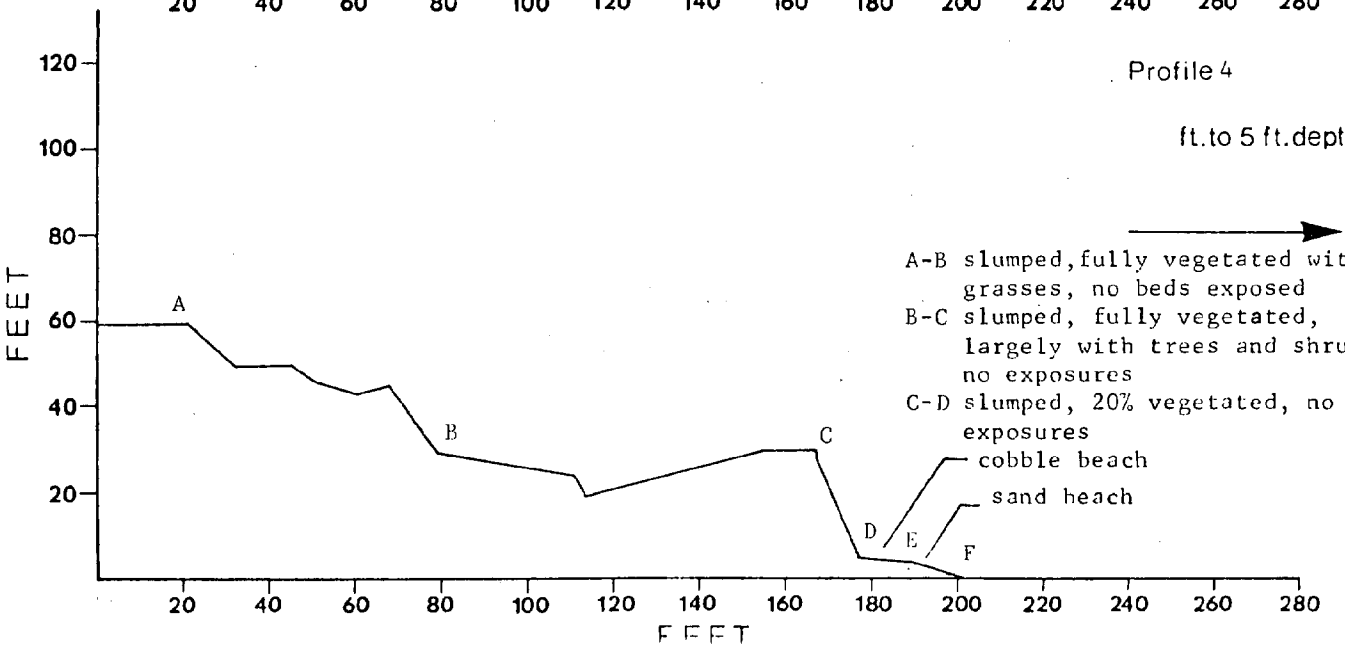
Profile

ft. to 5 ft. depth



Profile 4

ft. to 5 ft. depth



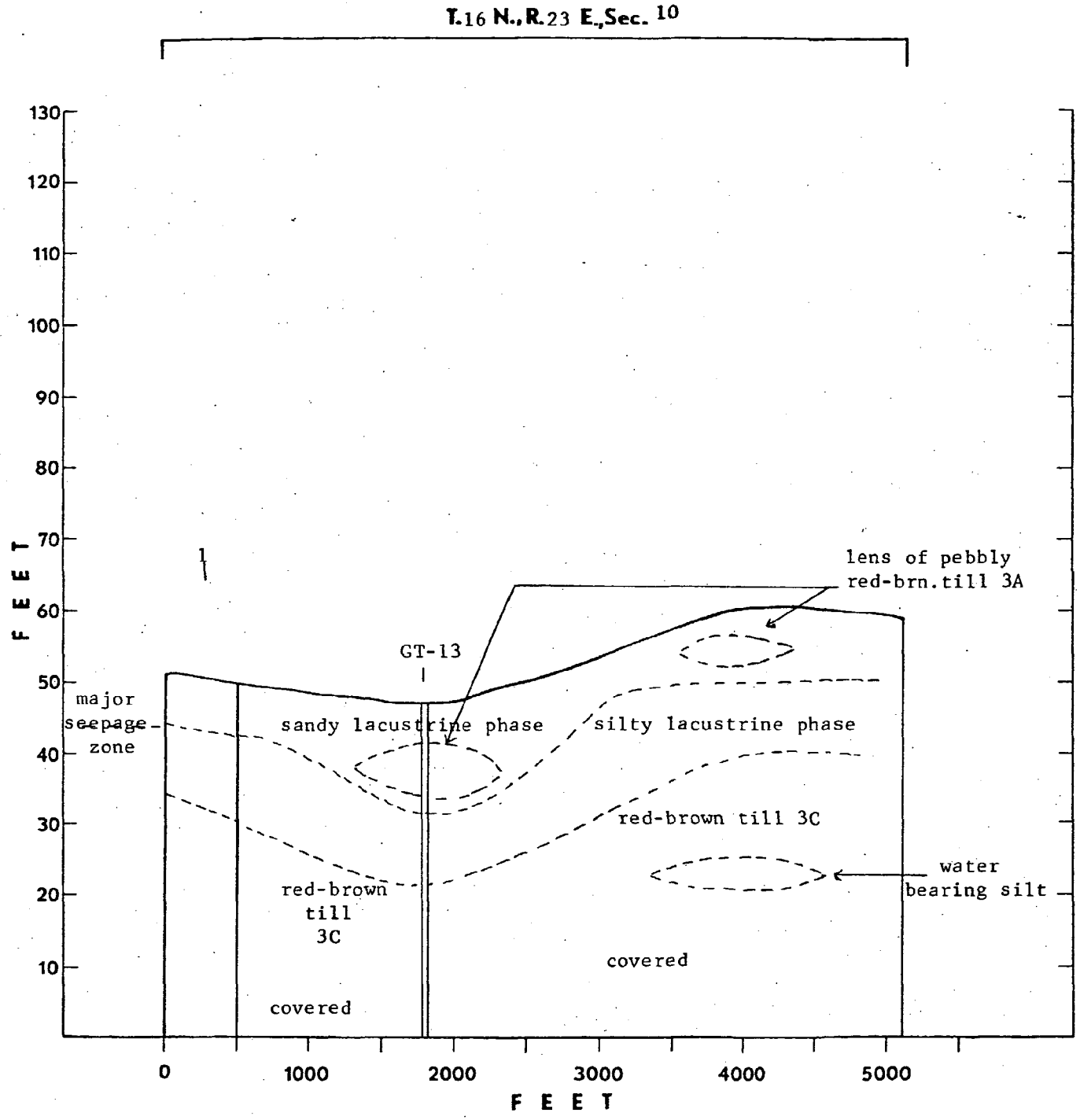
A-B slumped, fully vegetated with grasses, no beds exposed

B-C slumped, fully vegetated, largely with trees and shrubs no exposures

C-D slumped, 20% vegetated, no exposures

cobble beach

sand beach


T.16 N., R.23 E., Sec. 10
130
120
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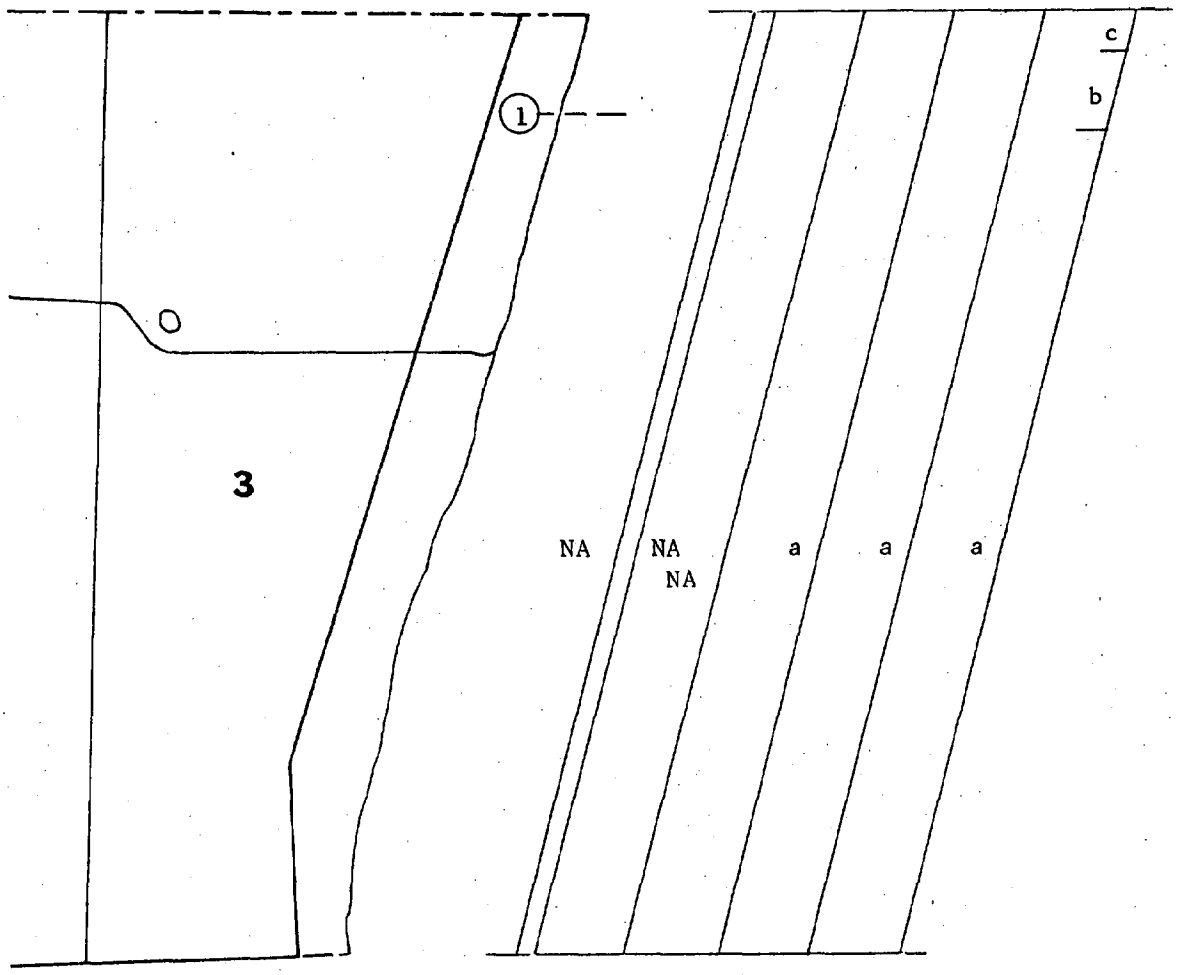
80
70
60
50
40
30
20
10
FEET
1
lens of pebbly
red-brn.till 3A
GT-13
major
seepage
zone
sandy lacustrine phase
silty lacustrine phase
red-brown till 3C
water
bearing silt
red-brown
till
3C
covered
covered
0
1000
2000
3000
4000
5000
FEET

110



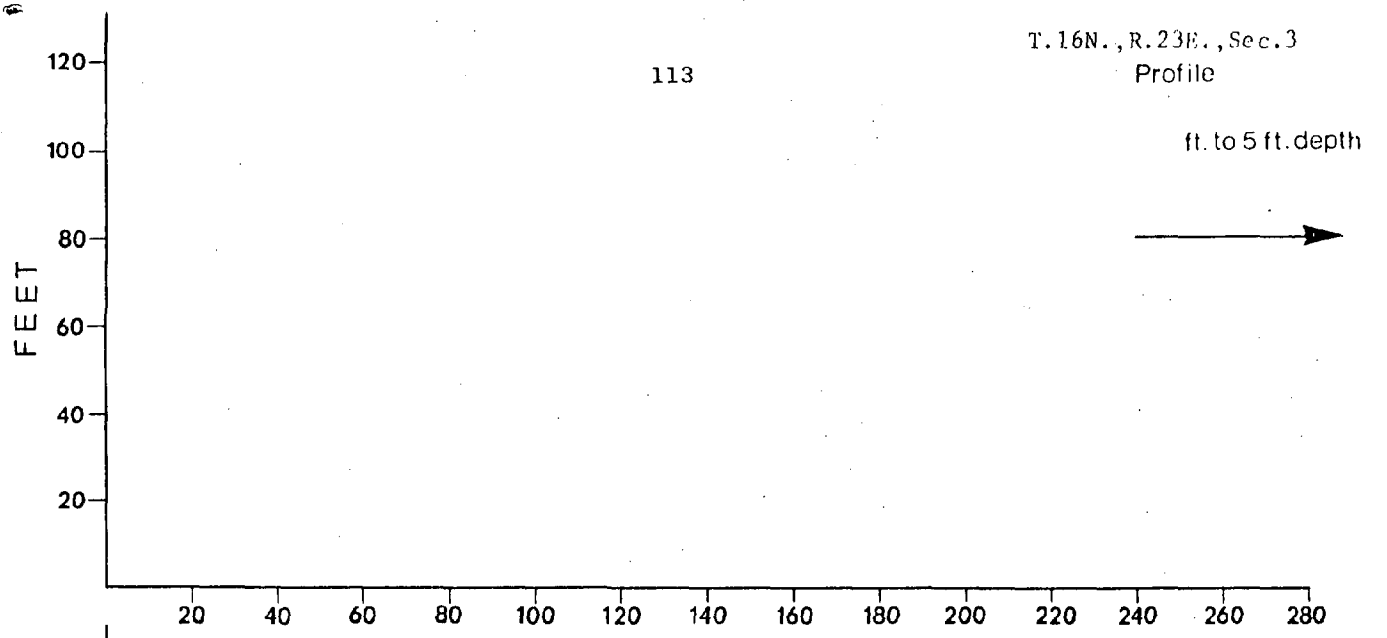
3 E.

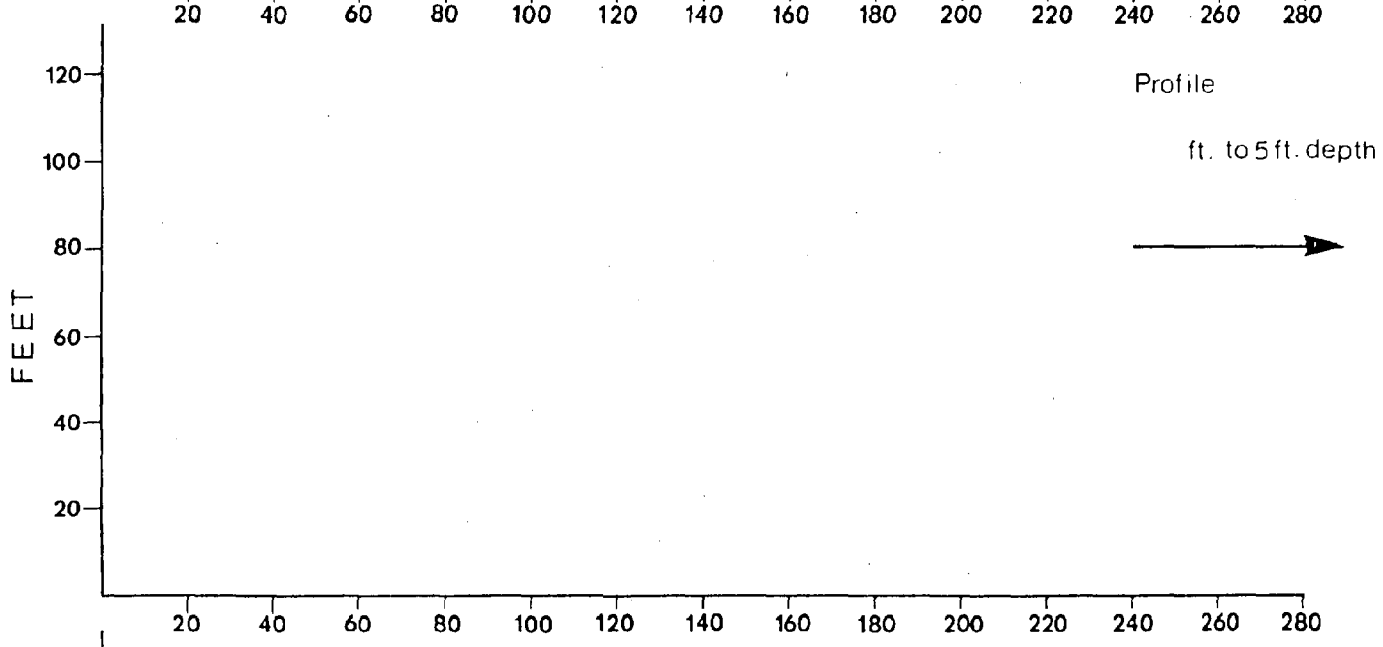
SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

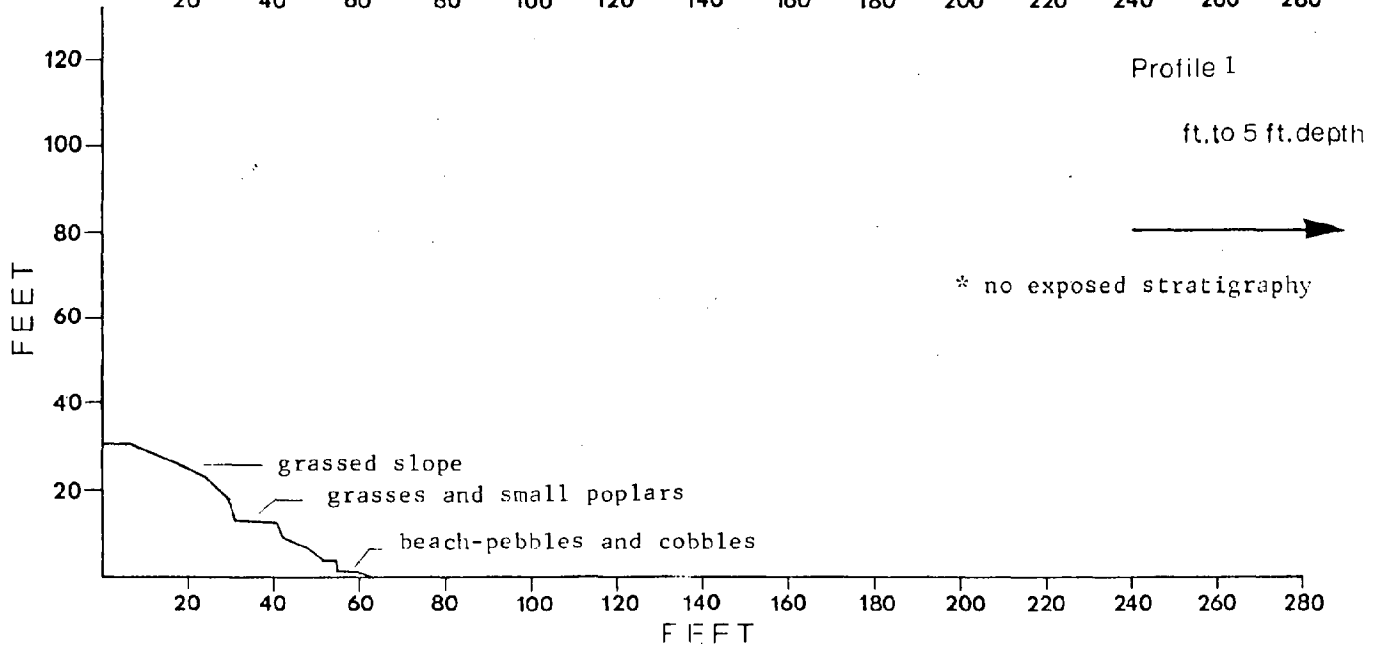
CONFIDENCE LEVEL
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

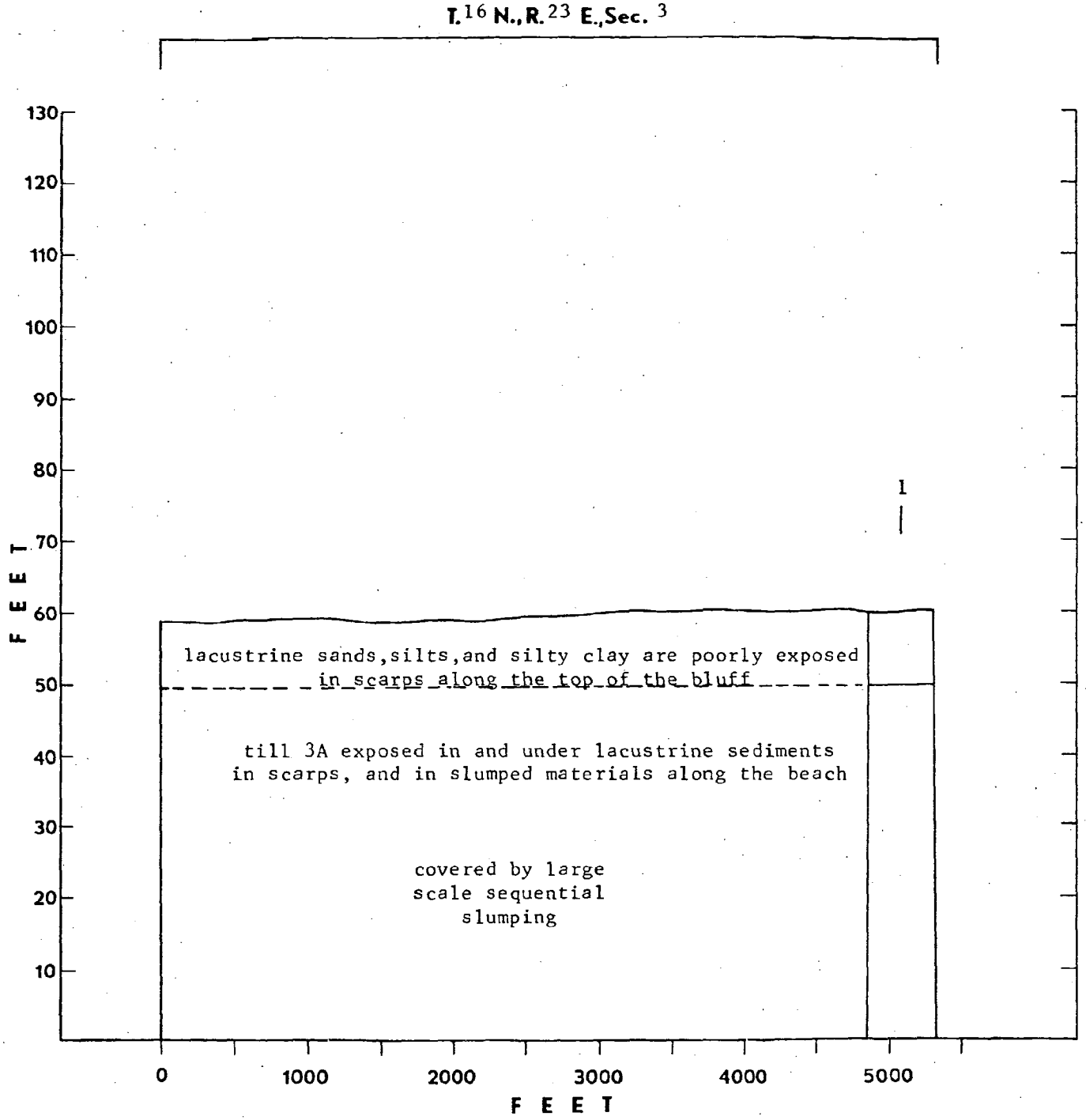
1. BLUFF	a-large scale sequential slumping of entire face			
2. TOE	a-slumped till '3A', sands, and silt			
3. BEACH	a-0-30 ft. cobbles	b-5-30 ft. sand, cobbles, and boulders	c-25 ft. sand and cobbles	

T.16N., R.23E., Sec.3








T.16 N., R.23 E., Sec. 3
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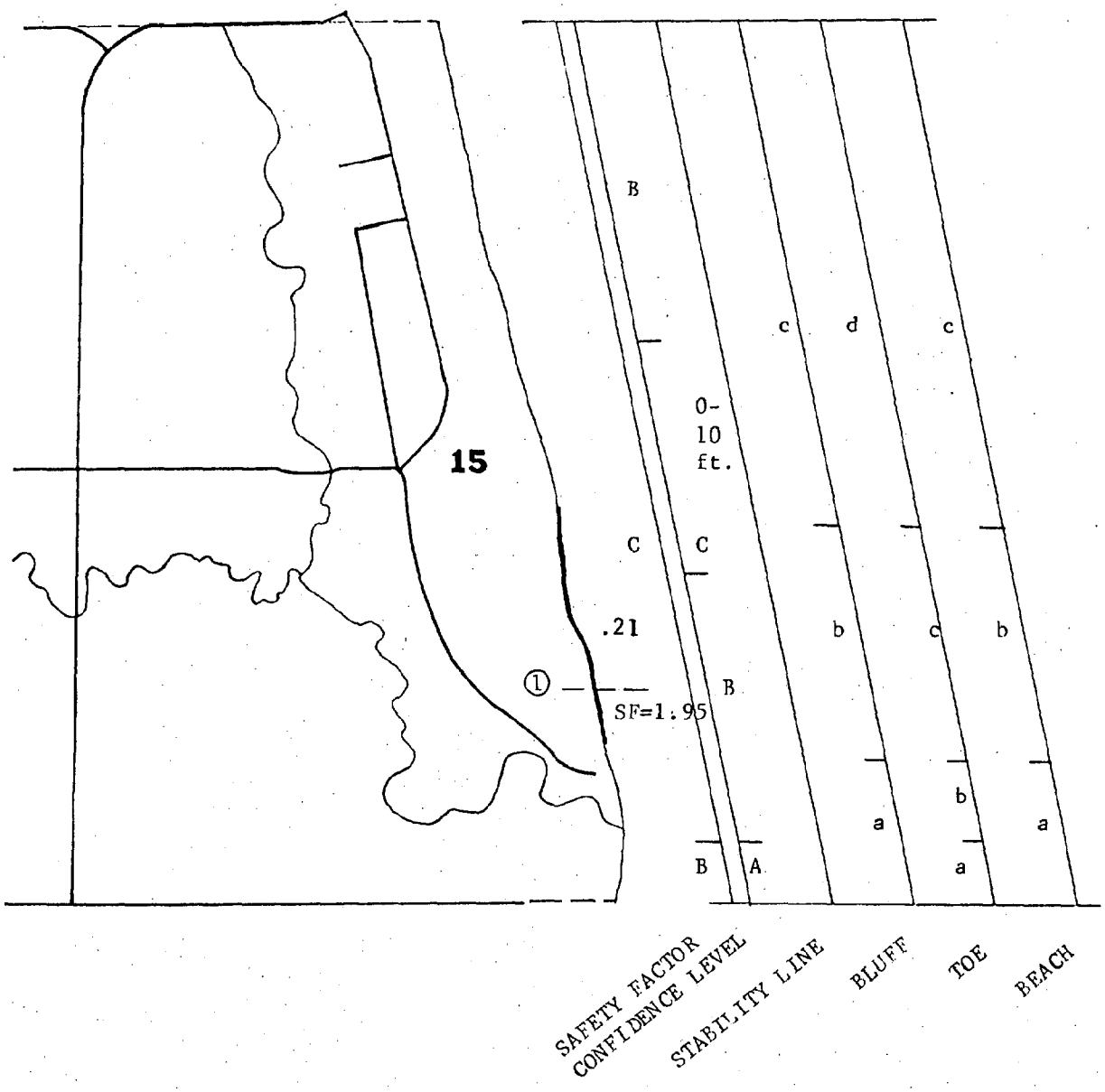
10
FEET
1
lacustrine sands, silts, and silty clay are poorly exposed in scarps along the top of the bluff
till 3A exposed in and under lacustrine sediments in scarps, and in slumped materials along the beach
covered by large scale sequential slumping
0
1000
2000
3000
4000
5000
FEET

T.16N.,R.23E.,Sec.15



SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

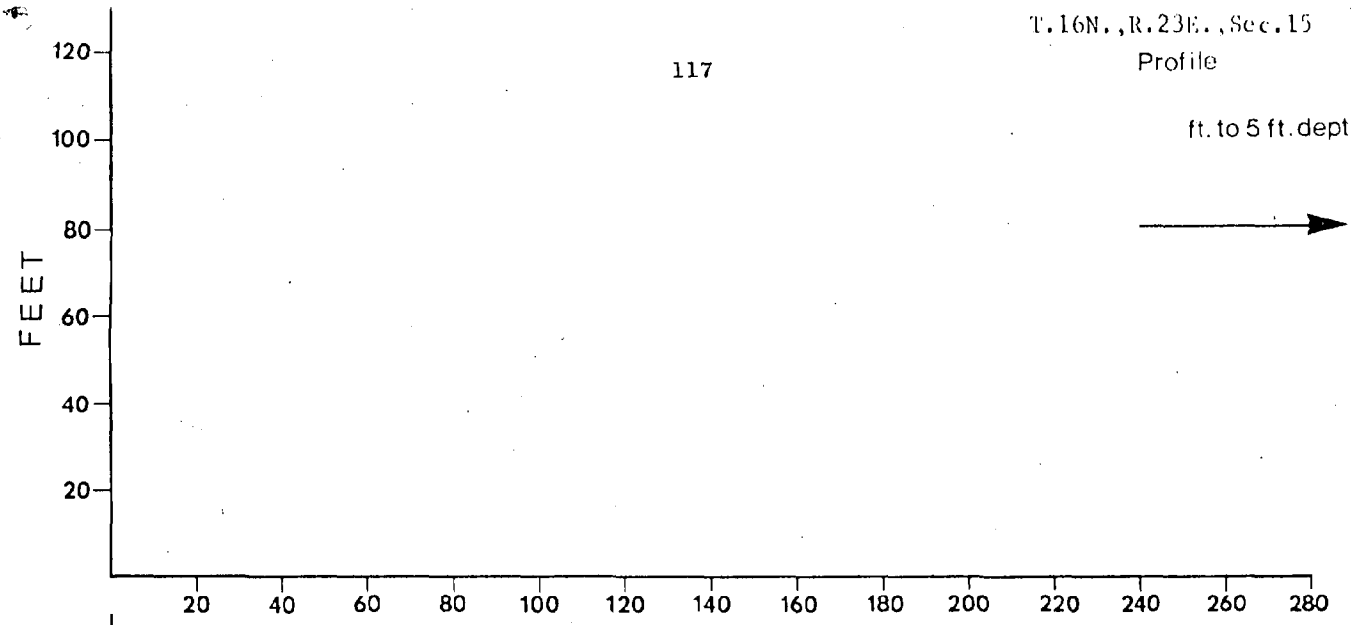
A-boreholes (high confidence)
B-near boreholes stratigraphy visible
C-no stratigraphy visible (low confidence)

1. BLUFF	a-no bluff	b-grassed and stabilized slope behind revetment	c-large scale sequential slumping involving full face	
2. TOE	a-till '3C'	b-alluvium	c-revetment	d-slumped till and silt
3. BEACH	a-15-35 ft. pebbles and cobbles	b-no beach	c-10-40 ft. cobbles	

T.16N.,R.23E.,Sec.15

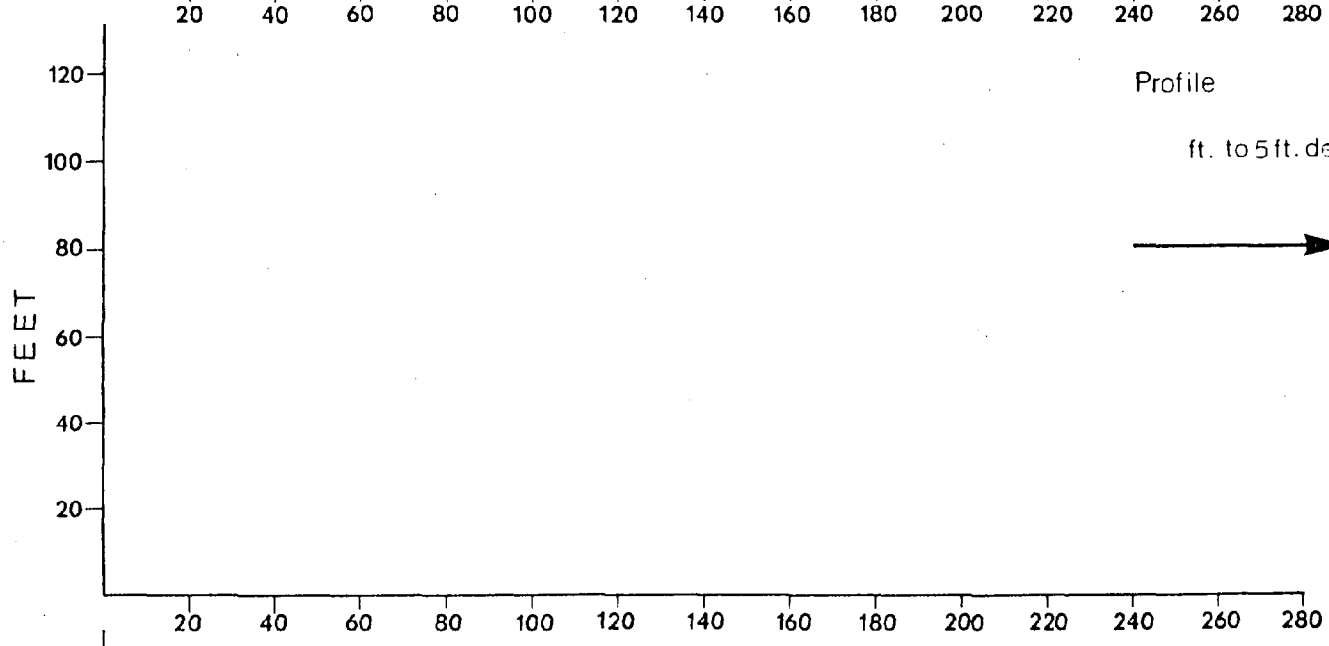
Profile

ft. to 5 ft. depth



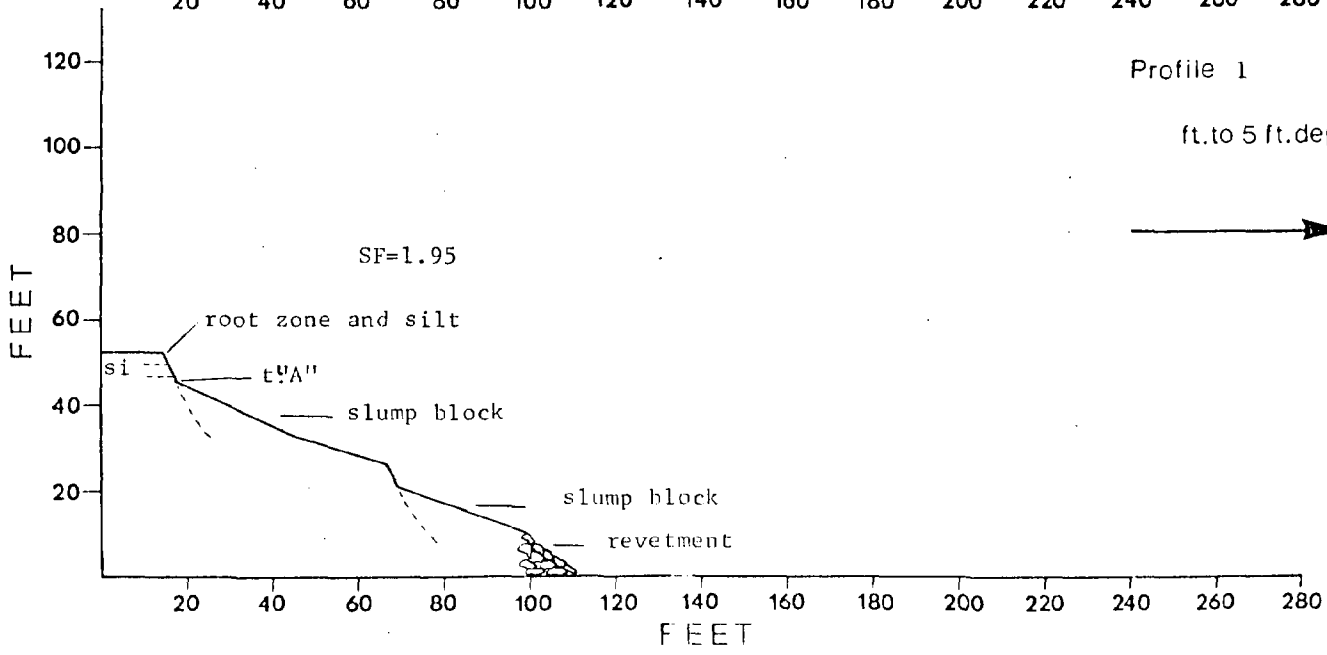
Profile

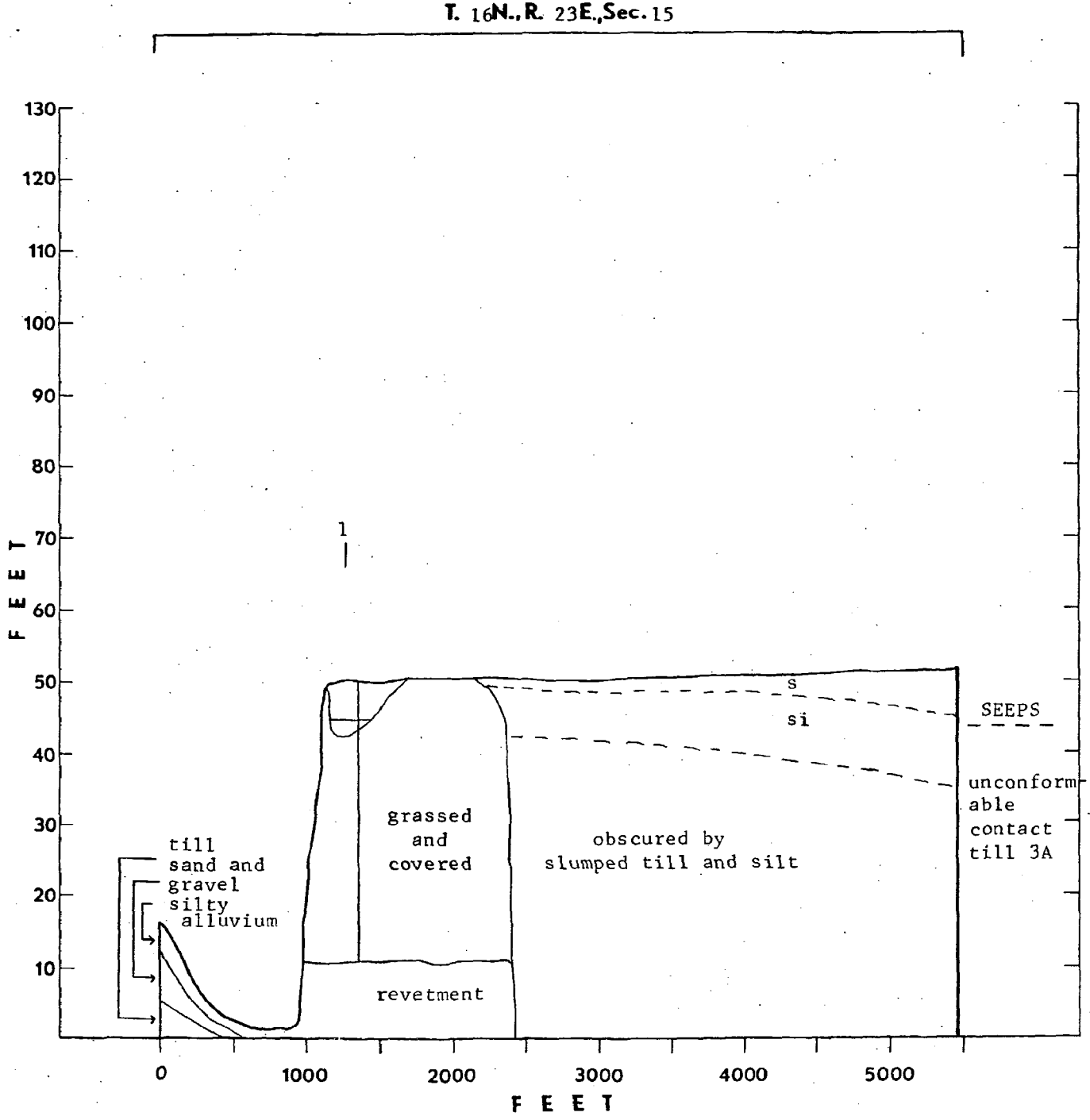
ft. to 5 ft. depth



Profile 1

ft. to 5 ft. depth




T. 16N., R. 23E., Sec. 15
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contact
till 3A
grassed
and
covered
obscured by
slumped till and silt
till
sand and
gravel
silty
alluvium
revetment
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2000
3000
4000
5000
FEET